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1998

Summary of Research 1998, Department of Electrical and Computer Engineering

Faculty of the Department of Electrical and Computer
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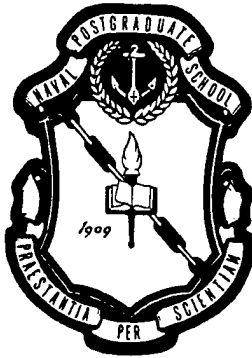
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SUMMARY OF RESEARCH 1998

**Department of
Electrical and Computer Engineering**

**Jeffrey B. Knorr
Chair**

**Murali Tummala
Associate Chair for Research**

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Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral R.C. Chaplain, USN
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Provost

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This report contains summaries of research projects in the Department of Electrical and Computer Engineering. A list of recent publications is also included which consists of conference presentations and publications, books, contributions to books, published journal papers, technical reports, and thesis abstracts.

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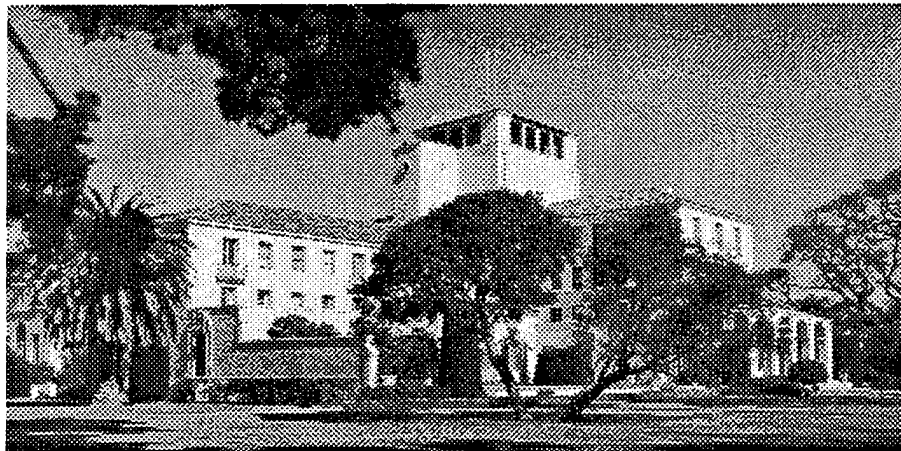
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**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**Jeffrey B. Knorr
Chair**

THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges.



CONTENTS

Preface	7
Introduction	9
Faculty Listing	11
Department Summary	13
Project Summaries	19
Signal-to-Noise Enhancement Program (SNEP) Research and Support	19
Field Station Research and Support	20
Converter Design, Analysis, and Prototype for Future Navy Surface Ships	21
Advanced Processor and Memory Systems	22
Network Simulation for Advance Amphibious Assault Vehicle (AAAV)	22
Design of Irredundant Sum-of-Products Computer-Aided Design (CAD) Tools	22
The Simulation and Digital-Signal-Processing (DSP) Implementation of Closed-Loop Auxiliary Resonant Commutated Pole (ARCP) Control Algorithms for Inverter and Boost Rectifier Applications	23
Signal Classification Issues Using Wavelet-Based Features	24
Feature Extraction for Signal Characterization in Classification Applications	25
Design of a Microelectronic Controller and Tactor Interface Integrated Circuit (IC) for the Tactile Situational Awareness System	26
Radiation Tolerant Bulk CMOS Digital Integrated Circuits	26
The Military Application of MEO and ICO Commercial Satellite Systems	27
Processing of Radar Signals Using Correlation and Wavelet Concepts	27
Processing of Second Order Statistics via Wavelet Transforms	28
Evaluation and Extensions of the Probabilistic Multi-Hypothesis Tracking (PMHT) Algorithm to Cluttered Environments	28
Development of Parabolic Equation Model Over Rough Surface	29
Compute Modeling Techniques for Array Antennas on Complex Structures	30
Correlation Interferometry Direction Finding (CIDF) Reflector Antenna	31
Monolithic Microwave Integrated Circuit (MMIC) Receiver for Air Traffic Collision Avoidance	31
Time Domain Simulation of Receiving Systems Using MATLAB/SIMULINK Communications Toolbox	32
Electromagnetic Characterization of Metallic Platforms via Eigen-Function Analysis	32
Hands-On Short Course on Computer Modeling and Simulation in Electromagnetics, Communications and Radar	33
Classic Diamondback Universal Mast Sleeve Antenna Study	33
Project Gusty Oriole	34
Asynchronous Transfer Mode (ATM) Compressed Video Bitstream Modeling and Analysis for Information Warfare	35
IT-21 Vulnerability Assessment	35
Wireless Local Area Network (LAN) Analysis	36
Internetworking Analysis for Counternarcotics Information Operations	36
Modeling and Simulation of ATM Transport Mechanisms in Large-Scale Networks for Projection of Information Operations	37
Organizational Collaboration in a Globally Networked Environment	37
Uninterruptable Power Supply Design for the AN/MRC-142 Communication System	38
Radiation Hardened Space Based Solar Cells and Electronic Devices	39
Enhanced Electro-Magnetic (EM) Radiation Source Imaging	40
Impulse Antenna Modeling	40
Ultra-Wideband Impulse Antenna Design	41
Wideband Low-Profile Communication Antenna Design	41

Improvement in Anti-Ship Cruise Missile (ASCM) Threat Simulator Modeling and Simulation Technology	41
Digital Target Imaging Architectures	43
Experimental Investigation of a High-Speed High-Resolution Direction Finding Array	44
Methods for Performance Analysis of Heat Dissipating Structures	45
Photonic Sampling Architectures for Microwave Signal Collection and Analysis	46
Airplatform Survivability Enhancement	47
Fast Frequency-Hopped Digital Communication	48
Geolocation Improvements at Low Latitudes	49
Beartrap Post-Mission Analysis System	49
Multi-Sensor Data Fusion for the Vessel Traffic Services System	50
Phase Adjustment Control for Loran-C Applications	51
Traffic Characterization and Scheduling Issues in Multimedia Wireless Networks	51
Relocatable Regional Satellite-Based Tactical Mobile Telephone Network	52
Single Event Upset (SEU) Immune Low Temperature Grown GaAs Integrated Circuits	52
Radiation Hardness Analysis of InP and SiGe Technologies for Space Applications	53
Time Resolved Single Event Studies in Silicon on Insulator (SOI)	54
Low-Band Harm Assessments and Evaluations – Phase One	55
Economical SAR/ISAR System Development for Unmanned Aerial Vehicle (UAV) Applications – Phase One	55
Wireless Damage Control Computer Networks	55
Accurate Control of Manipulators Using Inertial Sensors	56
Traction Control of Autonomous All-Terrain Robotic Vehicles	57
Publications and Presentations	59
Thesis Abstracts	67
Initial Distribution List	103

PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the School's eleven academic departments, seven interdisciplinary groups, and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty in the Department of Electrical and Computer Engineering during 1998. Also included is an overview of the department, faculty listing, a compilation of publications/presentations, and abstracts from theses directed by the department faculty.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the NPS Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing militarily relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, permitting them to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. This capability is especially important at the present time when technology in general, and information operations in particular, are changing rapidly. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focussed graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at NPS consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with other government laboratories and universities, provides off-campus courses either on-site at the recipient command or by VTC, and provides short courses for technology updates.
- **NPS Institutionally Funded Research Program (NIFR):** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursable sponsored, (4) to contribute to the recapitalization of major scientific equipment, and (5) to cost-share the support of a strong post-doctoral program.
- **Institute for Joint Warfare Analysis (IJWA) Program:** The IJWA Program provides funding to stimulate innovative research ideas with a strong emphasis on joint, interdisciplinary areas. This funding ensures that joint relevance is a consideration of research faculty.

In 1998, the overall level of research effort at NPS was 145 faculty workyears and exceeded \$35 million. The Department of Electrical and Computer Engineering's effort was 17.85 faculty workyears and exceeded \$3.6 million. The sponsored research program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY98, over 81% percent of the NPS research program was externally supported. In the Department of Electrical and Computer Engineering 86% was externally supported.

The department's research sponsorship in FY98 is provided in Figure 1.

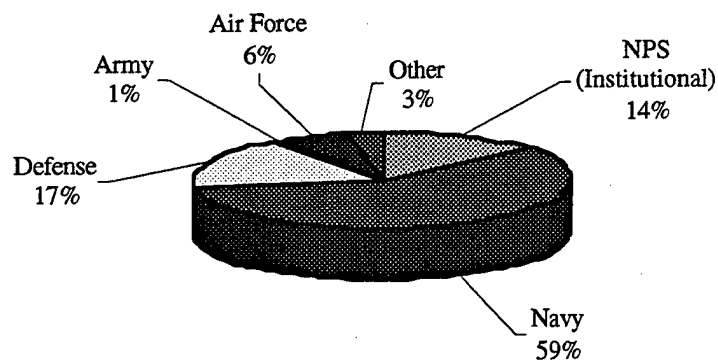


Figure 1. FY98 Sponsor Profile of the Department of Electrical and Computer Engineering

These are both challenging and exciting times at NPS and the research program exists to help ensure that we remain unique in our ability to provide graduate education for the warfighter.

DAVID W. NETZER
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October 1999

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DEPARTMENT SUMMARY

The research program of the Department of Electrical and Computer Engineering (ECE) is very broad, reflecting the variety of skills and interests of the faculty in providing technical advances and solutions to important problems for the Navy and the Department of Defense. In addition to being DoD relevant, research in ECE is strongly coupled to instruction, both in bringing the most recent advances into the classroom and in providing highly relevant and unique thesis topics for officer students to investigate under faculty guidance.

Research in the Department of Electrical and Computer Engineering is supported by an internally funded research program called the NPS Institutionally Funded Research (NIFR) program, and an externally funded research program called the Reimbursable Research (RR) program. The NIFR program includes a Research Initiation Program (RIP) for new faculty and also provides funding for new initiatives, meritorious projects, cost sharing, and a postdoctoral program. The Reimbursable Research program includes those projects that are externally supported by a wide range of government agencies, and by private industry through Cooperative Research and Development Agreements (CRADAs).

In FY 1998, ECE Department reimbursable research totaled \$3.59M. A total of 17.85 faculty research work years were executed, representing 50% of the Department faculty labor. The department's research work led to 14 journal papers, 60 conference papers/presentations, 4 book chapters, and 15 technical reports. These publications are listed following the Research Project Summaries.

Research projects in the department can be grouped into the following specialty areas: Communications; Communication Networks; Computer Engineering; Electromagnetics; Guidance, Navigation, and Control; Infra-Red and Electro-Optics; Microelectronics; Power Electronics, Electrical Machines and Distribution; Radar, Surveillance, and Information Warfare; Signal Processing/Underwater Acoustics; and Signals Intelligence/Space Systems. Following this introduction is a listing of 1998 research project titles and principal investigators, by specialty area. Although some projects span more than one area, they are listed in only one.

Complete Project Summaries appear following the specialty area listing. These Summaries appear in alphabetical order, according to the principal investigator's surname. Publications, presentations, and theses associated with each project are listed. The student thesis involvement in faculty research is evidence of the strong interaction between the department's teaching and research programs.

Communications

THE MILITARY APPLICATION OF MEO AND ICO COMMERCIAL SATELLITE SYSTEMS

Tri T. Ha, Professor

Vicente Garcia, National Security Agency Cryptologic Chair Professor

TIME DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

FAST FREQUENCY-HOPPED DIGITAL COMMUNICATION

R. Clark Robertson, Professor

Communication Networks

NETWORK SIMULATION FOR AAHV

Raymond F. Bernstein Jr., Research Associate Professor

ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

WIRELESS LOCAL AREA NETWORK (LAN) ANALYSIS

John McEachen, Assistant Professor

DEPARTMENT SUMMARY

INTERNETWORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor

MODELING AND SIMULATION OF ATM TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS

John McEachen, Assistant Professor

ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT

John McEachen, Assistant Professor

TRAFFIC CHARACTERIZATION AND SCHEDULING ISSUES IN MULTIMEDIA WIRELESS NETWORKS

Murali Tummala, Professor

RELOCATABLE REGIONAL SATELLITE-BASED TACTICAL MOBILE TELEPHONE NETWORK

Don Wadsworth, Senior Lecturer

WIRELESS DAMAGE CONTROL COMPUTER NETWORKS

Xiaoping Yun, Associate Professor

Computer Engineering

ADVANCED PROCESSOR AND MEMORY SYSTEMS

Raymond F. Bernstein Jr., Research Associate Professor

DESIGN OF IRREDUNDANT SUM-OF-PRODUCTS CAD TOOLS

Jon T. Butler, Professor

Electromagnetic Systems

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

R. W. Adler, Research Associate Professor

W. R. Vincent, Visiting Research Associate

FIELD STATION RESEARCH AND SUPPORT

R. W. Adler, Research Associate Professor

DEVELOPMENT OF PE MODEL OVER ROUGH SURFACE

R. Janaswamy, Associate Professor

COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES

David C. Jenn, Associate Professor

CIDF REFLECTOR ANTENNA

Jeffrey B. Knorr, Professor

Beny Neta, Professor

MMIC RECEIVER FOR AIR TRAFFIC COLLISION AVOIDANCE

Jeffrey B. Knorr, Professor

ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

DEPARTMENT SUMMARY

HANDS-ON SHORT COURSE ON COMPUTER MODELLING AND SIMULATION IN ELECTROMAGNETICS, COMMUNICATIONS AND RADAR

Jovan Lebaric, Visiting Associate Professor
Robert Vitale, Microwave Lab Director

CLASSIC DIAMONDBACK UNIVERSAL MAST SLEEVE ANTENNA STUDY

Jovan Lebaric, Visiting Associate Professor
Richard Adler, Research Associate Professor

ENHANCED EM RADIATION SOURCE IMAGING

Michael A. Morgan, Professor

IMPULSE ANTENNA MODELING

Michael A. Morgan, Professor

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor
R. Clark Robertson, Professor

WIDEBAND LOW-PROFILE COMMUNICATION ANTENNA DESIGN

Michael A. Morgan, Professor

GEOLOCATION IMPROVEMENTS AT LOW LATITUDES

Rasler W. Smith, Research Assistant Professor
Richard W. Adler, Research Associate Professor
Gus K. Lott, Assistant Professor

Guidance, Navigation, and Control

PHASE ADJUSTMENT CONTROL FOR LORAN-C APPLICATIONS

Murali Tummala, Professor
Roberto Cristi, Associate Professor

ACCURATE CONTROL OF MANIPULATORS USING INERTIAL SENSORS

Xiaoping Yun, Associate Professor

TRACTION CONTROL OF AUTONOMOUS ALL-TERRAIN ROBOTIC VEHICLES

Xiaoping Yun, Associate Professor

Infra-Red and Electro-Optics

PHOTONIC SAMPLING ARCHITECTURES FOR MICROWAVE SIGNAL COLLECTION AND ANALYSIS

John P. Powers, Professor
Phillip E. Pace, Associate Professor

Microelectronics

DESIGN OF A MICROELECTRONIC CONTROLLER AND TACTOR INTERFACE IC FOR THE TACTILE SITUATIONAL AWARENESS SYSTEM

Douglas J. Fouts, Associate Professor

DEPARTMENT SUMMARY

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

Douglas J. Fouts, Associate Professor

METHODS FOR PERFORMANCE ANALYSIS OF HEAT DISSIPATING STRUCTURES

Ron J. Pieper, Visiting Associate Professor

SEU IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford Assistant Professor

Douglas Fouts Associate Professor

Power Systems

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

Robert William Ashton, Associate Professor

THE SIMULATION AND DSP IMPLEMENTATION OF CLOSED-LOOP ARCP CONTROL ALGORITHMS FOR INVERTER AND BOOST RECTIFIER APPLICATIONS

John G. Ciezki, Assistant Professor

UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC-142 COMMUNICATION SYSTEM

Sherif Michael, Associate Professor

Radar, Surveillance, and Information Warfare

EVALUATION AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING (PMHT) ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor

THEATER BALLISTIC MISSILE DEFENSE (TBMD) – MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor

H.A. Titus, Professor Emeritus

IT-21 VULNERABILITY ASSESSMENT

John McEachen, Assistant Professor

IMPROVEMENT IN ASCM THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor

DIGITAL TARGET IMAGING ARCHITECTURES

Phillip E. Pace, Associate Professor

EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAYS

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

AIRPLATFORM SURVIVABILITY ENHANCEMENT

R. Clark Robertson, Professor

Frederick Levien, Senior Lecturer

DEPARTMENT SUMMARY

LOW-BAND HARM ASSESSMENTS AND EVALUATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor

ECONOMICAL SAR/ISAR SYSTEM DEVELOPMENT FOR UAV APPLICATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor

Signal Processing/Underwater Acoustics

SIGNAL CLASSIFICATION ISSUES USING WAVELET-BASED FEATURES

Monique P. Fargues, Associate Professor

FEATURE EXTRACTION FOR SIGNAL CHARACTERIZATION IN CLASSIFICATION APPLICATIONS

Monique P. Fargues, Associate Professor

TIME DIFFERENCE OF ARRIVAL ESTIMATION BASED ON WAVELET SCALES

Ralph D. Hippenstiel, Associate Professor

Tri T. Ha, Professor

PROCESSING OF RADAR SIGNALS USING CORRELATION AND WAVELET CONCEPTS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

MULTI-SENSOR DATA FUSION FOR THE VESSEL TRAFFIC SERVICES SYSTEM

Murali Tummala, Professor

Signals Intelligence/Space Systems

PROJECT GUSTY ORIOLE

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RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES

Sherif Michael, Associate Professor

TIME RESOLVED SINGLE EVENT EFFECT STUDIES IN SOI

Todd Weatherford, Assistant Professor

RADIATION HARDNESS ANALYSIS OF InP AND SiGe TECHNOLOGIES FOR SPACE APPLICATIONS

Todd Weatherford, Assistant Professor

PROJECT SUMMARIES

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

Richard W. Adler, Research Associate Professor

Wilbur R. Vincent, Visiting Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Security Group Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites and Regional Security Operational Centers (RSOCs) worldwide.

SUMMARY: Development of techniques and methodology for identifying and locating radio noise sources of interference to data processing and computer systems at NSG sites worldwide continued. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans, and authoring "Quick-Look" and final site-survey reports. Students and NSG site personnel were trained as part of the NSG support. A 2-day conference, HF Technical Review of Factors that Affect Performance of Naval Receiving Sites, was organized and was held in Washington DC in May.

OTHER:

Vincent, W.R., Adler, R.W., and Parker, A.A., "The EMI Aspects of Grounds at Receiving and Data Processing Sites," Technical Memorandum, Signal Enhancement Laboratory, Naval Postgraduate School, Monterey, CA, March 1998.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Program Signal Quality Survey NSGA Rota," Quick-Look Report, prepared for COMNAVSECGRU N-44, 10 June 1998.

Vincent, W.R. and Adler, R.W., "System Performance Survey NSGA Naples," Technical Report, prepared for COMNAVSECGRU N-44, March 1998.

Vincent, W.R. and Adler, R.W., "Signal-to-Noise Enhancement Team Survey NSGA Sabana Seca," Technical Report, prepared for COMNAVSECGRU N-44, September 1998.

Vincent, W.R. and Adler, R.W., "Field Exercises on Power-Line-Noise Source-Location Techniques at NSGD San Diego," Data Summary Report, prepared for COMNAVSECGRU N-44, September 1998.

Vincent, W.R., "New Radar Engineers Noise Receiver," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "HF Power-Line-Noise Sensors," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Differential Probe," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Equipotential Ground Experiment," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Cable Tests," prepared for USA INSCOM for presentation at the Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Fusion Lights," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

PROJECT SUMMARIES

Vincent, W.R., "Installation Standards," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Vincent, W.R., "Standing Waves on Grounds," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Perry, R., "Motor Controller Status," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

Parker, A.A., "Summary of Winter Harbor EMI Problem," prepared for COMNAVSECGRU N-44 Yearly SNEP Program Review, Ft. Meade, MD, May 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

FIELD STATION RESEARCH AND SUPPORT
Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: U.S. Army Information Security Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Army Regional Security Operational Centers (RSOC) and receiving sites worldwide.

SUMMARY: An EMI survey was conducted at the RSOC, Ft. Gordon, GA. The performance of receiving signals-of-interest at the RSOC was evaluated and the EMI sources observed were documented.

OTHER:

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Quick-Look Report, prepared for USA INSCOM, January 1998.

Vincent, W.R., Adler, R.W., and Parker, A.A., "The EMI Aspects of Grounds at Receiving and Data Processing Sites," Technical Memorandum, Signal Enhancement Laboratory, Naval Postgraduate School, Monterey, CA, March 1998.

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Technical Report, prepared for USA INSCOM, May 1998.

Vincent, W.R. and Adler, R.W., "Signal Quality Survey at the Ft. Gordon Regional Security Operations Center (GRSOC)," Quick-Look Report, prepared for USA INSCOM, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Environmental Effects)

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

PROJECT SUMMARIES

CONVERTER DESIGN, ANALYSIS, AND PROTOTYPE FOR FUTURE NAVY SURFACE SHIPS

Robert William Ashton, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Annapolis Detachment

OBJECTIVE: Four 100kW buck choppers are currently part of small-scale dc zonal electric distribution system at the Naval Surface Warfare Center (NSWC). The object of this research is to assist in creating two 200kW buck choppers from the existing four 100kW units. This will require hardware changes and major control algorithm modifications. The units are to be paralleled with a non-droop method and share current equally excluding sensor inaccuracies.

SUMMARY: During FY97 the Programmable Universal Controller (PUC) was developed and implemented. The PUC, designed by NSWC personnel, was adopted by this investigator as the second generation controller. The PUC is TMS320 based with ten available 200kHz A/D converters for acquiring sensor information. The PUC uses a computer for interfacing, and many PUCs may be daisy-chained via fiber optic cable. Electrical isolation is accomplished by the use of fiber optic cable to the power section transistor driver board, the computer interface board and all follow-on PUCs. Each PUC can control two converters simultaneously. This required the building of three PUCs, two for NSWC and one for the NPS testbed. Documentation of the PUC had to be generated since little was available from NSWC due to personnel changes.

Two prototype 9kW buck choppers that interface with the PUC were designed, built, and tested. These converters are closely matched so that future paralleling requirements could be implemented. After a PUC was built and tested, assembler code for the TMS320 was developed to run the choppers. The original multi-loop algorithm used in the first generation controller was coded and burned into the EPROMs. The NPS testbed which includes one PC, one PUC, and two 9kW buck choppers was completed. After debugging, the converters were successfully operated at their full-power ratings.

At this point an interface card for the 100kW units at NSWC was designed, cut, populated and tested at NPS. This card is required for local control, several protection features and the special Power Paragon Inc. (PPI) IGBT driver boards. All necessary components for the new controllers were shipped to Annapolis for integration with the power sections. The converters were made operational with the new controllers and were then shipped to PPI, Anaheim, CA for upgrades and permanent hardwiring for parallel operation at 200kW.

During FY98 a new algorithm for paralleling the units without droop was needed and NPS was given the task of developing, testing, and incorporating this new algorithm on the modified power converters. The new algorithm uses a master/slave technique that incorporates current differences in the paralleled units' inductors and outputs to maintain identical current sharing. After successful simulation and hardware testing in the NPS Power Systems Laboratory, the new algorithm was implemented successfully at PPI and the units paralleled 200kW units were shipped back to Annapolis.

PUBLICATIONS:

Ashton, R.W. and Ciezki, J.G., "The Formulation and Implementation of an Analog/Digital Control System for a 100kW DC-to-DC Buck Chopper," *ISCAS 98*, Vol. III, p. 489, Monterey, CA, June 1998.

Ashton, R.W., Ciezki, J.G., and Badorf, M.G., "The Synthesis and Hardware Validation of DC-to-DC Converter Feedback Controls," *PESC 98*, Vol. 1, p. 65, Tokyo, Japan, June 1998.

Ciezki, J.G. and Ashton, R.W., "The Design of Stabilizing Controls for Shipboard DC-to-DC Buck Choppers Using Feedback Linearization Techniques," *Proceedings of PESC 98*, Vol. 1, p. 335, Tokyo, Japan, June 1998.

THESIS DIRECTED:

Floodeen, D.L., "Implementing Desired Control Algorithms for Auxiliary Resonant Commutated Pole PWM Inverters Using Existing DSP Resources," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Energy Conversion)

PROJECT SUMMARIES

KEYWORDS: Power Electronic Building Blocks, Power System, DC Distribution, Zonal Architecture, Stability, Simulator

ADVANCED PROCESSOR AND MEMORY SYSTEMS

Raymond F. Bernstein Jr., Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School Foundation, Inc.

OBJECTIVE: To design large-scale integrated circuits (VLSI) for a vector pipelined processor architecture.

SUMMARY: Two chips are under study in this task. One chip performs the function of interfacing banked memories using permutation-based decoding to a bus. The second chip is a pipelined vector processor that performs radix-r butterfly operations, complex vector addition, and multiplication.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Vector Processor, Pipelining, Digital Signal Processing

NETWORK SIMULATION FOR ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV)

Raymond F. Bernstein Jr., Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Advanced Amphibious Assault Vehicle Technology Center

OBJECTIVE: To simulate the FDDI, CANBus, and Utility bus and their associated computers to stress test the system to determine required improvements in the system.

SUMMARY: The three networks (FDDI, CANBus, Utility bus) used in the AAAV were analyzed. This project began in late November and has been focused on data collection and analysis for this simulation. A simulation of the three networks has been partially developed and will be completed in the following year.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Networks, Network Simulation, FDDI

DESIGN OF IRREDUNDANT SUM-OF-PRODUCTS COMPUTER-AIDED DESIGN (CAD) TOOLS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: The goal of this research is to develop improved algorithms for the minimization of irredundant sum-of-products expressions, which are used in almost all CAD tools. Two subgoals are to understand the extent to which a heuristic can fail (produce a large irreducible sum-of-products expression) and why it fails. A goal will be to develop a paradigm by which good heuristics can be produced.

SUMMARY: Initiated a study of Reed-Muller expressions for realizing compactly digital logic functions. This is a collaborative effort with Professor Gerhard Dueck of St. Francis Xavier University, Antigonish, NS, Canada, and two visiting professors at St. Francis Xavier University. Under this joint research project (funded also by NSERC of Canada and St. Francis Xavier University), a fast algorithm was identified for finding the optimum Reed-Muller expansion for symmetric

PROJECT SUMMARIES

circuits. A surprising result of this work is that only two of the 2^{**n} expansions of n -variable functions produce optimum realizations (40% of the functions are optimally realized by the two expansions). Presently, three publications are in progress on this work.

PUBLICATIONS:

Sasao, T. and Butler, J.T., "Worst and Best Irredundant Sum-of-Products Expressions," *IEEE Transactions on Computers*, submitted.

Butler, J.T. and Sasao, T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," *Proceedings of the International Symposium on Multiple-Valued Logic*, pp. 83-88, May 1998.

CONFERENCE PRESENTATIONS:

Butler, J.T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," to be presented at the 29th International Symposium on Multiple-Valued Logic, Freiburg, Germany, 1999.

Butler, J.T., "On the Properties of Multiple-Valued Functions That are Symmetric in Both Variable Values and Labels," International Symposium on Multiple-Valued Logic, Fukuoka, Japan, 26 May 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Logic Circuit Design, CAD (Computer-Aided Design), Compact Circuits

THE SIMULATION AND DIGITAL-SIGNAL-PROCESSING (DSP) IMPLEMENTATION OF CLOSED-LOOP AUXILIARY RESONANT COMMUTATED POLE (ARCP) CONTROL ALGORITHMS FOR INVERTER AND BOOST RECTIFIER APPLICATIONS

John G. Ciezki, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: Research engineers at the Navy's government laboratories are actively engaged in producing the hardware elements required for implementing a dc zonal distribution system for the Surface Combatant of the twenty-first century. One of the key components of that system is the Auxiliary Resonant Commutated Pole (ARCP) Inverter which will be used bidirectionally to either create ac from dc or series connected to implement a fixed-frequency to variable-frequency converter. The ARCP is to be controlled by the Power Electronic Building Block Universal Controller (PUC) developed by personnel at the Naval Surface Warfare Center (NSWC). The investigator seeks to develop the control algorithms necessary to implement the closed-loop operation of the ARCP. In particular, it is proposed to use simulation to validate a series of voltage-based and current-based feedback control laws which can then be coded and implemented with the PUC. The control algorithms will be implemented in the stationary and synchronous reference frames and will use pulse-width-modulation and space vector techniques for realizing the switching times. In addition, the investigator will derive a soft-switched boost rectifier algorithm via simulation and aid researchers at NSWC in implementing the derived control using the PUC. The products of this research will consist of a series of technical reports documenting the algorithms and a set of ACSL computer simulation models that will be delivered to NSWC personnel.

SUMMARY: The investigator completed work in the following four areas: ARCP inverter control algorithms, PUC C++ routines, dc-dc converter algorithms, and boost rectifier analysis. The investigator first developed a digital simulation of the inverter module using ACSL. Two algorithms were developed to regulate the current out of the inverter and one algorithm was developed to regulate the 3-phase voltage out of the inverter. One final algorithm was developed to regulate the startup and speed control of a 3-phase symmetrical induction machine. All algorithms were validated through simulation and documented as to how they would be implemented using the PUC. In addition, the current-control algorithms were further

PROJECT SUMMARIES

validated using the dSPACE development resources and additional hardware [Frasz, 1998]. To support the rapid determination of control gains for the aforementioned algorithms, various MATLAB programs were written. Programming the PUC with C++ algorithms was unsuccessful due to the memory mapping of the board as found in Floodeen, 1998. Since this endeavor was not possible, the investigator included research into decentralized control of dc-dc converters which is being extended by Moore, 1999. A signal-injection algorithm was identified, analyzed and various MATLAB script files were assembled to facilitate the analysis and selection of gains. The final aspect of the work revolved around the simulation and analysis of a three-phase boost rectifier employing an ARCP topology. A boost converter feedback control was derived, a detailed simulation implemented in both single-phase and three-phase, and a means for transitioning between the three phases established. The work reported here is being extended into a number of thesis projects: paralleling ARCP inverters [Marinac, 1999], de-centralized control of dc-dc converters [Moore, 1999] and current-mode control of dc-dc converters [Hekman, 1999].

PUBLICATION:

Ciezki, J.G. and Ashton, R.W., "The Application of a Customized DSP Board for the Control of Power Electronic Converters in a DC Zonal Electric Distribution System," *Proceedings of the 32nd Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, November 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Energy Conversion)

KEYWORDS: Power Electronic Converters, High-Bandwidth Controllers, Power Electronic Building Block

SIGNAL CLASSIFICATION ISSUES USING WAVELET-BASED FEATURES

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Undersea Warfare Center-Newport and Naval Postgraduate School

OBJECTIVES: The goal of the on-going study is to: 1) investigate the application of wavelet-based decompositions to the classification of signals with narrowband characteristics and 2) to conclude a previous investigation applying Wiener filter concepts to wavelet denoising.

SUMMARY: This study conducted during FY98 was split into two parts. First, the application of wavelet-based decompositions to the classification of non-stationary signals with narrowband characteristics were investigated. The literature in this area was reviewed. The Least Discriminant Bases (LDB) scheme was implemented, and the Learned and Willsky's feature extraction scheme and compared their performances when applied to narrowband-like signals. Next, several dimension reduction schemes were considered and a new one called the Mean Separator Neural Network (MSNN) was proposed. Two types of classifiers were considered and compared: classification trees and back-propagation neural networks. Comparisons between different types of dimension reduction and classifiers were conducted both on synthetic and real-world underwater data. Results showed that the MSNN is a viable tool for classification of signals with narrowband characteristics.

Second, the study started during FY97 was concluded which considered the application of Wiener filter concepts to wavelet-based denoising. Results show performances to be quite sensitive to signal types, and that no distinct advantages over wavelet thresholding techniques for a wide range of signals is obtained.

PUBLICATION:

Fargues, M. and Duzenli, O., "Wavelet-Based Feature Extraction Methods for Classification Applications," *Proceedings of the 9th Signal Processing Workshop on Statistical Signal and Array Processing*, pp. 176-179, September 1998.

PROJECT SUMMARIES

THESES DIRECTED:

Forney, F.D., Jr., "Acoustic Noise Removal by Combining Wiener and Wavelet Filtering Techniques," Master's Thesis, Naval Postgraduate School, June 1998.

Cebeci, C., "Denoising of Acoustic Signals Using Wavelet/Wiener Based Techniques," Master's Thesis, Naval Postgraduate School, June 1998.

Duzenli, O., "Classification of Underwater Signals Using Wavelet Based Decompositions, Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Software)

KEYWORDS: Wavelet, Classification

FEATURE EXTRACTION FOR SIGNAL CHARACTERIZATION IN CLASSIFICATION APPLICATIONS

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force

OBJECTIVES: The goal of the study is to extend a dimension reduction scheme considered in previous work and to consider its applications to classification applications.

SUMMARY: In a previous study a new dimension reduction scheme was proposed to reduce the dimension of the feature space generated to characterize signal classes. This initial scheme, called the Mean Separator Neural Network, was designed to distinguish between two classes only. In this work, the scheme was extended to more than two classes. The results obtained were compared to other types of dimension reduction techniques proposed in the literature. Next, a simple decision scheme was proposed which can be used with the MSNN to generate a complete classifier at a cheap computational cost. Simulations to compare classification performances were conducted both on synthetic and underwater data. Results show our proposed overall classification scheme to have performances similar to those obtained with more expensive schemes on the data considered.

PUBLICATION:

Fargues, M. and Duzenli, O., "Dimension Reduction Issues in Classification Applications," *Proceedings of the 32nd Asilomar Conference on Signals, Signals, and Computers*, November 1998.

THESIS DIRECTED:

Duzenli, O., "Classification of Underwater Signals Using Wavelet Based Decompositions," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices, Software)

KEYWORDS: Wavelet, Classification

PROJECT SUMMARIES

DESIGN OF A MICROELECTRONIC CONTROLLER AND TACTOR INTERFACE INTEGRATED CIRCUIT (IC) FOR THE TACTILE SITUATIONAL AWARENESS SYSTEM

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Naval Aerospace Medical Research Laboratory

OBJECTIVE: To develop a wearable (small, lightweight, and low power) microelectronic controller for the Tactile Situational Awareness System (TSAS) developed by the U.S. Naval Aerospace Medical Research Laboratory (NAMRL). To develop a specification for the tactor interface and to design a custom digital integrated circuit for communicating with the tactor.

SUMMARY: TSAS is a new combat aviation situational awareness system, developed by NAMRL that allows aircraft avionics systems to communicate directly with the pilot through the use of touch using a device called a tactor. The specification of an interface standard for tactors has been successfully completed. The design of a wearable (small, lightweight, and low power) microelectronic controller for TSAS has been completed. The components required to construct the controller are on order. The design of a tactor interface integrated circuit to allow the controller to communicate with an array of up to 256 tactors has been completed. The chip has been fabricated and tested but did not work due to fabrication errors. The design is being submitted again to obtain a working part.

THESIS DIRECTED:

Luke, B., "Design of a Microelectronic Controller with MIL-STD-1553 Bus Interface," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: Wearable Computing, Microelectronics, Tactile Communications

RADIATION TOLERANT BULK CMOS DIGITAL INTEGRATED CIRCUITS

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Space Systems Academic Group

Sponsor: National Security Agency

OBJECTIVE: To develop circuit designs and mask layout techniques that improve the radiation tolerance of digital integrated circuits fabricated with standard, commercial, bulk CMOS processes for use in low-earth orbit spacecraft and high altitude aircraft.

SUMMARY: Work is concentrating in two areas. First, reducing subthreshold, gate, end-around leakage current which is caused by radiation-induced charge in the field oxide along the edge of the conducting channel of the transistor. This effort has been very successful. Second, compensating for shifts in threshold voltage that are caused by radiation-induced charge in the gate oxide. To date this effort has been promising but the work is still in progress and conclusive data is not yet available.

PUBLICATION:

Fouts, D.J., Noe, S.S., Lum, G.K., Lambley, A.S., and McKerrow, G.R., "Second-Layer Polysilicon Structures for Gate End-Around Leakage Current Compensation in Bulk CMOS ICs," *IEEE Transactions on Nuclear Science*, submitted.

PROJECT SUMMARIES

THESIS DIRECTED:

McKerrow, G.R., "Design Rules for Radiation-Tolerant CMOS ICs Fabricated with Commercial Bulk Processes," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control, and Communications, Electronic Warfare

KEYWORDS: Radiation-Hardened Electronics, Space Electronics

THE MILITARY APPLICATION OF MEO AND ICO COMMERCIAL SATELLITE SYSTEMS

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Vicente Garcia, National Security Agency Cryptologic Chair

Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: To produce a model that is capable of accommodating the less initial needs and requirements of U.S. MILSATCOM by utilizing the services provided by MEO and ICO satellite systems.

SUMMARY: A comprehensive model architecture consisting of ICO, Teledesic, and GBS was developed. This model accommodated narrowband, wideband, and broadcast requirements of U.S. MILSATCOM in addition to the communication needs of a model UN peacekeeping mission. The application of these systems to U.S. MILSATCOM coincided with the U.S. defense doctrine of a CONUS-based military with the capability of rapid global power projection to respond to crises throughout the global arena. Instead of investing heavily in new satellite systems, the U.S. military could use the forthcoming commercial LEO and MEO systems to meet the information requirements of tactical commanders.

PUBLICATION:

Kakavas, I., Ha, T.T., and Garcia, V., "The Military Applications of MEO and ICO Commercial Satellite Systems," Naval Postgraduate School Technical Report, NPS-EC-98-014, 15 September 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MEO, ICO, MILSATCOM

PROCESSING OF RADAR SIGNALS USING CORRELATION AND WAVELET CONCEPTS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: Investigate wavelet processing of second order statistics obtained from frequency agile radars with variable pulse repetition frequency (PRF).

SUMMARY: Radar characteristics of systems of interest were obtained. Typical attributes of representative electronic signatures were simulated using MATLAB. Initial results indicated that the correlation-based approach was not suitable for pulsed signals. This result was in contrast to the results obtained when dealing with constant envelope signals (i.e., fre-

PROJECT SUMMARIES

quency hopped signals). Work is in progress concentrating on using the wavelet transform directly in the time domain. One student is involved in the research.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: Radar Signals, Signal Detection/Classification, Identification

PROCESSING OF SECOND ORDER STATISTICS VIA WAVELET TRANSFORMS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop and investigate the properties of a wavelet based approach in detecting and classifying digital modulated signals. A wavelet transform, replacing the traditional Fourier transform in the computation of the time-frequency distribution, is used to obtain a scale-time/delay distribution. Also transformations of the generated distribution to its co-domains will be addressed.

SUMMARY: Wavelets were used to identify the modulation type of digital communication signals. In addition, parameters of interest were extracted. The processing is based on the 2-dimensional instantaneous correlation function. Both domains, time and delay, were used to in the wavelet based analysis. Based on simulation, processing performance versus signal-to-noise ratio was obtained.

PUBLICATION:

Hippenstiel, R., Fargues, M., Khalil, N., and Overdyk, H., "Processing of Second Order Statistics via Wavelet Transforms," Naval Postgraduate School Technical Report, NPS-EC-98-005, 20 February 1998.

CONFERENCE PRESENTATION:

Hippenstiel, R.D. and Fargues, M.P., "Processing of Second Order Statistics Via Wavelet Transforms," SPAWAR, Chantilly, VA, 7 April 1998.

DoD TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: Wavelets, Time Frequency Distributions, Signal Detection/Classification

EVALUATION AND EXTENSIONS OF THE PROBABILISTIC MULTI-HYPOTHESIS TRACKING (PMHT) ALGORITHM TO CLUTTERED ENVIRONMENTS

Robert G. Hutchins, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Undersea Warfare Center-Newport

OBJECTIVE: To improve shallow water tracking of quiet submarines using sensor fusion and an advanced PMHT algorithm.

SUMMARY: Traditional multiple hypothesis tracking algorithms seek to enumerate all possible combinations of measurement-to-track data associations, maintaining a goodness of fit score for each association. Because computers have finite memories and the combinatorial possibilities of assigning even a few time sets of measurements to different possible

PROJECT SUMMARIES

combinations of tracks quickly becomes astronomical, all possible hypotheses cannot be maintained over time. Hence, only the most likely subset of hypotheses is maintained, and tracks, associations, and hypotheses themselves are increased and pruned over the course of an engagement to maintain an acceptable memory load. Hence, multiple hypothesis algorithms have been limited in their applications. Doctor Roy Streit and colleagues at NUWC have developed a new approach to multiple hypothesis target tracking that features a probabilistic approach to the measurement-to-track assignment problem. The PMHT algorithm circumvents the need for enumeration of measurement-to-track assignments, as well as pruning.

This algorithm is still under development, and extensions to critical practical areas is ongoing. Here at the Naval Postgraduate School, the Principal Investigator has conducted research into the extension of the algorithm to cluttered environments, specifically for tracking active sonar targets. Also, an investigation into the attribute-augmented assignment problem has been undertaken, and the modified algorithm has been compared with other existing tracking and assignment algorithms. This past year's effort focused on statistical attributes and the use of multiple maneuver models to aid tracking.

PUBLICATIONS:

Dunham, D.T. and Hutchins, R.G., "Tracking Multiple Targets in Cluttered Environments with a Probabilistic Multi-Hypothesis Tracker," *Studies in Probabilistic Multi-Hypothesis Tracking and Related Topics*, Vol. SES-98-01, Roy L. Streit, (ed.), Chapter 14, Naval Undersea Warfare Center Division, Newport, RI, 1998.

Hutchins, R.G. and Dunham, D.T., "Evaluation of a Probabilistic Multi-Hypothesis Tracking Algorithm in Cluttered Environments," *Studies in Probabilistic Multi-Hypothesis Tracking and Related Topics*, Vol. SES-98-01, Roy L. Streit (ed.), Chapter 15, Naval Undersea Warfare Center Division, Newport, RI, 1998.

Hutchins, R.G. and Dunham, D.T., "Evaluation and Extensions of the Probabilistic Multi-Hypothesis Tracking Algorithm to Cluttered Environments," Naval Postgraduate School Technical Report, NPS-EC-98-015, January 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Sensors, Modeling and Simulation

KEYWORDS: Kalman Filters, Sensor Fusion, Multi-Target Tracking, Littoral Warfare

DEVELOPMENT OF PARABOLIC EQUATION MODEL OVER ROUGH SURFACE

Ramakrishna Janaswamy, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Space and Naval Warfare Systems Center-San Diego and Naval Postgraduate School

OBJECTIVE: To explore alternate methods for fast prediction of radio propagation over rough ocean surface in the presence of ducting.

SUMMARY: The Navy is interested in assessing the effect of wind-driven roughness on the low grazing angle radio propagation over the ocean surface. The effect of roughness can be studied by looking at the equivalent impedance produced by the rough surface for the specular wave. An integral equation first needs to be solved before one can calculate the specular wave. The integral equation used earlier suffered from ill conditioning for large surface deviations. An extended integral equation based on Tikhonov's regularization scheme was considered to remove the ill conditioning. The regularization scheme significantly extended the range of applicability to larger wave heights. It was, however, demonstrated that choosing the regularization parameter was not a trivial task.

PROJECT SUMMARIES

PUBLICATION:

Janaswamy, R., "A Curvilinear Coordinate Based, Split-Step Parabolic Equation Method for Propagation Predictions Over Terrain," *IEEE Transactions on Antennas, Propagation*, Vol. 46, No. 7, pp. 1089-1097, July 1998.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Tropospheric Propagation, Rough Surfaces

COMPUTER MODELING TECHNIQUES FOR ARRAY ANTENNAS ON COMPLEX STRUCTURES

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: The objective of this research is to investigate the suitability of using several existing computational electromagnetics (CEM) codes in modeling antenna problems to predict the antenna's performance when it is in its operational environment; that is, when installed on a platform with other objects near it or in its field of view.

SUMMARY: Several off-the-shelf CEM codes have been used to model a wide range of antenna problems. They include simple dipoles and slots as well as microstrip patches and horns. These codes are well suited to the evaluation of antenna gain and pattern characteristics under various operational conditions. The purpose of this research was to demonstrate some of the features of the codes that are of use in the design and analysis of antennas on complex structures. The performance of individual elements and arrays of elements on complex structures has been computed using electromagnetic patch codes.

Many of the codes are derivatives of RCS prediction codes, and have been thoroughly validated. Furthermore, pre- and post-processing tools have been developed to generate geometry models and visualize data. Several military and civilian applications were presented in a master's thesis. They include antennas on an F-18, Cessna 172, and a communications pod under the wing of an F-18.

PUBLICATION:

Jenn, D.C., "Performance Evaluation of Antennas Installed on a Joint Standoff Weapon (JSOW) Captive Air Training Missile (CATM)," Naval Postgraduate School Technical Report, NPS-EC-98-008, 10 March 1998.

THESIS DIRECTED:

Calusdian, J., "Evaluation of Low-Gain Antennas on Aircraft," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Array Antennas, Computational Electromagnetics

PROJECT SUMMARIES

CORRELATION INTERFEROMETRY DIRECTION FINDING (CIDF) REFLECTOR ANTENNA

Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Beny Neta, Professor
Department of Mathematics
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this investigation was to study the application of the correlation interferometry direction finding algorithm to beamforming for a wide field of view reflector antenna, using computer simulation.

SUMMARY: This research was a preliminary investigation of the application of correlation signal processing to aperture antennas. Correlation is equivalent to matched filtering. In this application the result is spatial filtering. Processing a signal incident on an antenna in this way results in compression of the antenna beam solid angle and permits the angle of arrival of the incident signal to be determined. Thus, correlation signal processing can be employed to determine angle of arrival within the wider field of view of the antenna. Using this approach, one can simultaneously achieve both a wide instantaneous field of view and the ability to more precisely determine the angle of arrival.

Three aperture antennas were investigated; a high gain parabolic dish with Yagi feed, a high gain conical horn antenna fed from circular waveguide excited with an electric field probe, and an open ended circular waveguide, also excited with an electric field probe. In the case of the parabolic dish, the incident field was sampled at 36 points around the periphery of the dish. For the horn, the incident field was sampled at 24 points around the mouth of the horn. The field incident on the open ended waveguide was sampled at 16 points in the plane of the aperture using short dipoles that were arbitrarily located in the aperture plane at distances up to 6 times the radius of the waveguide. The results obtained for these three structures show that the beam solid angle of an aperture antenna can be successfully compressed and that the angle of arrival of an incident signal can be determined by sampling the incident field as described.

The most obvious application of the technique described here is signals intelligence where there is a requirement to geolocate intercepted signals.

PUBLICATION:

Knorr, J.B. and Neta, B., "Signal Processing for Aperture Antenna Beam Compression," Naval Postgraduate School Technical Report, NPS-EC-98-016, September 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Electronic Warfare, Modeling and Simulation, Sensors

KEYWORDS: Antennas, Beam Compression, Correlation Interferometry Direction Finding

MONOLITHIC MICROWAVE INTEGRATED CIRCUIT (MMIC) RECEIVER FOR AIR TRAFFIC COLLISION AVOIDANCE

Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Sponsor: Michigan Technological University

OBJECTIVE: The objective of this project was to construct a low cost receiver for a small aircraft traffic collision avoidance system using monolithic microwave integrated circuit technology.

SUMMARY: Although traffic collision avoidance systems (TCAS) systems have been developed for commercial aircraft, affordable systems for small aircraft are still not available. The focus of this project was to design and construct a low cost TCAS receiver using monolithic microwave integrated circuit (MMIC) technology. A receiver was designed using two commercially available ICs such that a hard limited output was produced for transponder inputs from other aircraft in the range from 0.25 to 40 nautical miles. The first IC served as a downconverter which translated the 1090 MHz aircraft

PROJECT SUMMARIES

transponder signal to an intermediate frequency of 50 MHz. The second IC was a logarithmic amplifier that provided the hard limited output. These were mounted on a printed circuit board that used microstrip circuitry as necessary for the RF and for LO signal frequency control. The receiver was powered by a single 5 Volt supply and required a current of about 100 mA. The total cost of the parts used to build the receiver was under \$25, excluding the printed circuit board which would be inexpensive to mass produce. The receiver is being tested and will be modified as necessary to achieve the desired performance during 1999. The receiver will be integrated with other TCAS subsystems at Michigan Technological University.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors

KEYWORDS: Air Traffic Collision Avoidance, TCAS

TIME DOMAIN SIMULATION OF RECEIVING SYSTEMS USING MATLAB/SIMULINK COMMUNICATIONS TOOLBOX

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To develop a toolbox model for signal intercept in the time domain including the signal sources, communication channels and receivers.

SUMMARY: Models of digital communication systems have been developed and implemented using Matlab/Simulink Communications Toolbox. The ability to detect and extract information in the presence of wideband noise and interference was verified via Monte Carlo type simulations in the time domain.

THESES DIRECTED:

Tsiridis, K., "Time Domain Simulation of MFSK Communications System Performance in the Presence of Wideband Noise and Co-Channel Interference," Master's Thesis, Naval Postgraduate School, December 1998.

Erdogan, V., "Time Domain Simulation of MPSK Communications System Performance in the Presence of Wideband Noise and Co-Channel Interference," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Communications, Modeling and Simulation

ELECTROMAGNETIC CHARACTERIZATION OF METALLIC PLATFORMS VIA EIGEN-FUNCTION ANALYSIS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop electromagnetic eigen-analysis software to electromagnetically characterize complex metallic platforms such as aircraft and ships.

SUMMARY: New capability has been developed for the electromagnetic eigen-analysis code EIGEN in order to enable faster eigen-analysis of wire grid models of electrically large metallic platforms. This includes faster matrix fill routines,

PROJECT SUMMARIES

iterative eigen-solver implementation, and 3D visualization of results. In addition, the visual graphical user interface (GUI) has been developed.

OTHER:

Lebaric, J., EIGEN 5.2 Electromagnetic Eigen-Analysis MATLAB Software

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Computational Electromagnetics, Antennas

HANDS-ON SHORT COURSE ON COMPUTER MODELING AND SIMULATION IN ELECTROMAGNETICS, COMMUNICATIONS AND RADAR

Jovan Lebaric, Visiting Associate Professor

Robert Vitale, Microwave Lab Director

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Crane Division

OBJECTIVE: To introduce the uses of commercial software MATHCAD, MATLAB, SIMULINK, Communications Toolbox, and NEC-WinPro for computer-based modeling and simulation in the areas of applied electromagnetics, communications, and radar.

SUMMARY: A 5-day hands on workshop was held at NSWC Crane to introduce applications of commercially available mathematical and engineering software to problems of antenna design and communications and radar systems modeling and simulation. The topics included both the theory and algorithm development and implementation.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Modeling and Simulation, Electromagnetics, Antennas, Radar

CLASSIC DIAMONDBACK UNIVERSAL MAST SLEEVE ANTENNA STUDY

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To determine the antenna options and parameters for designing an antenna system for the universal mast sleeve.

SUMMARY: The antenna classes that satisfy the electrical performance requirements (power, bandwidth, polarization, and beamwidth) and still conform to the space restrictions of the universal mast have been identified and their performance limitations identified and quantified.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Antennas, Communications

PROJECT SUMMARIES

PROJECT GUSTY ORIOLE

Herschel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

RADM Thomas C. Betterton, USN (Ret), Naval Space Technology Chair

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing, and communications of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and for SS4041 and SS4051, Military Space Systems and Technologies.

SUMMARY: Investigated algorithms and architectures of systems for the production, distribution, and analysis of tactical information. Investigated architectures of space-borne computer systems. Investigated operational problems concerned with the employment of tactical information for decision making and targeting. Planning a multi-source maritime situational awareness experiment for early 1999. Planned the inclusion of a major space system architecture study in SS4051 in winter 1999.

PUBLICATION:

Loomis, H.H., Jr. and Betz, J., "Low Probability of Intercept Communications (U)," *MILCOM98 Classified Conference Record*, MITRE Corp., Bedford, MA, October 1998.

CONFERENCE PRESENTATION:

Loomis, H.H., Jr. and Betz, J. "Low Probability of Intercept Communications (U)," MILCOM98 Classified Session, MITRE Corp., Bedford, MA, October 1998.

THESES DIRECTED:

Strozzo, P.G., "Detection and Classification of Digital Communication Signals Using Second and Higher Order Cyclostationary Features (Parts I & II) (U)," Master's Thesis, Naval Postgraduate School, June 1998.

Galina, J., "Maritime Situational Awareness-Dedicating the On-Board Processor for a Space Based Solution," Master's Thesis, Naval Postgraduate School, September 1998.

Jackson, A.K., "An Architecture for Maritime Situational Awareness," Master's Thesis, Naval Postgraduate School, September 1998.

Dines, S., "Space Based Information Operations," Master's Thesis, Naval Postgraduate School, December 1998.

Mateo, N., "The Effects of Time Varying Doppler on Cyclic Spectral Analysis," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Sensors

KEYWORDS: Tactical Information, Maritime Situational Awareness

PROJECT SUMMARIES

ASYNCHRONOUS TRANSFER MODE (ATM) COMPRESSED VIDEO BITSTREAM MODELING AND ANALYSIS FOR INFORMATION WARFARE

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Engineering Logistics Office and Naval Postgraduate School

OBJECTIVE: Develop models for efficient processing of compressed video and imagery observed over an ATM network. Establish a testbed high-speed network within NPS for testing and evaluation of networked video and imagery.

SUMMARY: The initial components for an ATM high-speed video network were identified, procured, installed, and configured resulting in a significant upgrade to the ECE department's networking laboratory facilities. The development of this lab has already benefited students in the EC3850 class. A commitment was obtained from NELO to cover the remaining shortfall in initial proposed DFR funding. The initial taxonomy and algorithms to be used in the analysis of video bitstreams has been developed. Additionally, software from interested DoD agencies was been acquired and installed. The final stage of this project involved designing and configuring an application using combined video and imagery to test the installation. The work resulted in the collaborative thesis of LTs Karl Thomas and Shawn Lobree.

THESIS DIRECTED:

Thomas, K.O. and Lobree, S.W., "A Demonstration and Analysis of Requirements for Maritime Navigation Planning," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

IT-21 VULNERABILITY ASSESSMENT

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To develop models and simulations of IT-21 specific standards-based digital communications networks using MIL3's OPNET network modeling software environment. Determine infrastructure constraints and vulnerabilities based on simulated results. This work is part of a continuing project with NELO.

SUMMARY: Two subprojects have been identified in relation to this project: 1) IT-21 standards-based software modeling for susceptibility analysis and 2) hardware simulation and testing. With respect to the first topic, a baseline simulation model has been developed of a projected IT-21 standards-based network. Additionally, two initial attack simulations have been developed and are under evaluation. Under the second subproject, a simulated IT-21 compliant wide area network (WAN) has been constructed in the Advanced Networking Laboratory using the SX-14 data channel simulator. Actual vulnerability analysis will begin upon arrival an Adtech AX/4000 test system (scheduled delivery Mar 99). Work on this project began in November 98.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

PROJECT SUMMARIES

WIRELESS LOCAL AREA NETWORK (LAN) ANALYSIS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Develop models for the assessment of wireless LAN performance over non-standard distances. Provide guidance and consultation on future initiatives in wireless LAN research.

SUMMARY: The OPNET Modeler network simulation tool will be used to simulate radio frequency (RF) environments where wireless LANs may be implemented. Issues relating to receiver sensitivity and performance in noisy environments will be examined. Work on this project began in November 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: 802.11, ATM, Wireless, LAN, High Speed Networking

INTERNETWORKING ANALYSIS FOR COUNTERNARCOTICS INFORMATION OPERATIONS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Develop methods for non-traditional analysis of computer network topologies, specifically those affiliated with the Internet. Recommend means for advanced use of network information in information operations. This work is part of a continuing project with the NSA.

SUMMARY: This project examines computer network topologies and operations in support of national security interests and is largely classified in nature. Recent initiatives within the NSA have produced highly unique data requiring more powerful analysis techniques. The initial stages of this research involved identifying key participants with a potential interest in this information. Additionally, specific areas for investigation were identified for further pursuit by NPS students. Finally, LT Eric Herbert completed his thesis in one of these areas, modeling telecommunications of financial data communications, in September 98. This work was presented at NSA in August 98. Ongoing work involves identifying new NPS students for thesis research in the remaining areas of interest and continued analysis of network trends.

CONFERENCE PRESENTATION:

McEachen, J.C., "Modeling Financial Transaction Networks," 1998 W Executive Council Seminar, National Security Agency, Ft. Meade, MD, 26 August 1998.

THESIS DIRECTED:

Herbert, E.W., "Telecommunications Vulnerability Analysis of Financial Transactions," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Internet, Counternarcotics, Network Analysis

PROJECT SUMMARIES

MODELING AND SIMULATION OF ATM TRANSPORT MECHANISMS IN LARGE-SCALE NETWORKS FOR PROJECTION OF INFORMATION OPERATIONS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Conduct analysis and evaluation of ATM facilities focusing on vulnerability identification and isolation through development of comprehensive large-scale digital communications network models using MIL3's OPNET network modeling software environment. This work is part of a continuing project with NELO.

SUMMARY: Analysis of a large-scale ATM network began by considering operation in a heterogeneous source environment. Specifically, a model examining the performance of a two-stage queuing system was developed, fed by a multiplexed Constant Bit Rate (CBR) source and a Poisson distributed source. The resulting D+M/D/1 waiting time tail distribution was approximated analytically using a weighted M/D/1 queuing system and used to verify the behavior of a computer model simulation. Cell loss encountered in the second stage is then observed for a variety of interarrival rates from the Poisson source. The work to date has presented a solid analytic foundation that will be further examined through theoretical analysis. Much of the queuing analysis of this project has also been applied to the design of a high-speed network interface.

PUBLICATION:

Batson, M.S. and McEachen, J.C., "Analysis Cell Loss in an ATM High-Speed Network Interface," Naval Postgraduate School Technical Report, NPS-EC-99-001, December 1998.

THESIS DIRECTED:

Batson, M.S., "Loss Performance in an ATM Cell Capture Environment," Master's Thesis, Naval Postgraduate School, December 1998.

OTHER:

Data Communication Analysis Tools Suite (DCATS). A new version of software protocol analysis tools consolidated at the request of a sponsor (NELO) and forwarded via DCS, 10 July 1998. These software tools allow near-real-time analysis of a large variety of data communication protocols in a user-friendly X-window based environment.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

ORGANIZATIONAL COLLABORATION IN A GLOBALLY NETWORKED ENVIRONMENT

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: IEEE Circuits and Systems Society

OBJECTIVE: Leveraging off cutting edge Internet technology, develop a network-centric system that facilitates the fundamental processes of conference organization and planning.

SUMMARY: Professional society conferences — such as the IEEE International Symposium on Circuits and Systems (ISCAS) or the IEEE Military Communications Conference (MILCOM) — are the primary mechanism for exchanging ideas on cutting edge research of vital interest to DoD. This project has identified and encapsulated the collaboration

PROJECT SUMMARIES

processes associated with organizing such conferences and created a system for researcher interaction on a global scale via the Internet.

Recent advances in database and networking technology allow the traditional processes for conference collaboration to be migrated to an on-line environment. Specifically, the recent development of Multi-part MIME encoding, Adobe Portable Document Format (PDF) and Open Database Connectivity (ODBC) worldwide web (WWW) gateways led to the implementation of a prototype system which allowed thousands of conference participants to submit documents using standard WWW browsing software for on-line consideration and review. Further, the review process itself as well as presentation scheduling, receipt verification and acknowledgement, and system administration are all facilitated with this system. Traditionally, this had been a highly labor intensive exercise involving several exchanges via postal mail and considerable expense. Some on-line conference organization systems have been implemented in the past, but none have approached the extent and robustness of the current effort.

PUBLICATION:

Coffman, J.W. and McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment," *Proceedings of the 1998 International Symposium on Circuits and Systems*, Vol. IV, pp. 33-36, Monterey, CA, June 1998.

CONFERENCE PRESENTATION:

McEachen, J.C., "A Paradigm for Collaboration Across a Globally Networked Environment," 1998 International Symposium on Circuits and Systems, Monterey, CA, 1 June 1998.

THESIS DIRECTED:

Coffman, J.W., "A Paradigm for Conference Collaboration Across a Globally Networked Environment," Master's Thesis, Naval Postgraduate School, March 1998.

OTHER:

ISCAS '98 WWW, E-mail, and Database Servers (<http://iscas.nps.navy.mil/>). A suite of servers was installed and configured for use by the ISCAS organizing committee and participants. These services included mass e-mail announcements, e-mail for committee members, paper submission, review dissemination and collection, scheduling, database access, and program generation. Records on over 3000 individuals were maintained. Over 1200 papers were collected and reviewed. The WWW site was visited over 5 million times as of December 1998.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Database, Internet, Common Gateway Interface, Worldwide Web (WWW), Networking

UNINTERRUPTABLE POWER SUPPLY DESIGN FOR THE AN/MRC-142 COMMUNICATION SYSTEM

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Marine Corps Systems Command

OBJECTIVE: To design and develop a prototype uninterruptable power supply. The result would be an improved power distribution panel that will provide the capability to manually switch between two ac sources, to the HMMWV dc battery/alternator or other dc sources. This would be accomplished with no interruption in the AN/MRC-142 communication system operation.

PROJECT SUMMARIES

SUMMARY: The research project tasks can be summarized as follows: 1) analyze and study the current existing AN/MRC-142 power distribution panel; 2) design and develop an uninterruptable power supply that will convert the selected ac source to 28v dc according to specifications, respond to monitor signals and initiate or terminate HMMWV charging, manual override switch for selection between either ac generator, automate switching between either generator and the HMMWV batteries, display panel for monitoring of the UPS operations, and protect against overvoltage of the ac generators; 3) modify the existing PDP to accommodate the above design within the same panel; and 4) complete implementation and testing of the developed UPS according to the enclosed specifications.

DoD KEY TECHNOLOGY AREA: Other (Electronic Devices)

KEYWORDS: AN/MRC-142 Marine Communication System, Uninterruptable Power Supply, Computer Modeling

RADIATION HARDENED SPACE BASED SOLAR CELLS AND ELECTRONIC DEVICES

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: To study the space radiation effects on state-of-the-art solar cells, including GaAs and InP cells. To investigate annealing methods developed in previous NPS research on the recovery of radiation degraded performance of advanced space cells and develop radiation hardened analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating the new laser annealing technique on GaAs and InP solar cells, and irradiating solar cells using the NPS Linear Accelerator and measuring their characteristics using the newly developed Solar Simulator facilities. Other tasks are to investigate radiation effects on different electronic devices and radiation testing of analog VLSI chips previously designed and fabricated using the NPS Linear Accelerator. Major research thrusts: annealing of radiation-damaged solar cells, investigating of laser annealing techniques for radiation damaged solar cells, and radiation tolerant ASIC and analog IC design, implementation, and testing.

PUBLICATION:

Pieper, R. and Michael, S., "Using PSPICE to Model the Cooling Performance of Convection Surfaces," *Proceedings of the 30th Southeastern Symposium on System Theory*, Morgantown, WV, pp. 85-90, March 1998.

THESIS DIRECTED:

Wilbur, M.J., "The VLSI Implementation of a GIC Switched Capacitor Filter," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Environmental Effects)

KEYWORDS: Space Radiation Effects, Satellites, Annealing, Radiation Hardened, Computer Modeling

PROJECT SUMMARIES

ENHANCED ELECTRO-MAGNETIC (EM) RADIATION SOURCE IMAGING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVE: This continuing research seeks to develop enhanced back-propagation algorithms for improved imaging of radiation sources using near-field measured data. Important technical issues involve discovery and development of the most useful technique for implementation with measured data. The form of this transformation is an issue, with integral equation and differential equation (e.g., finite element) based approaches possible, as well as hybrid methods. On-surface descriptions of signature sources can include physical currents or, more generally, equivalent currents (useful for apertures and volume sources such as penetrable composite materials). Algorithm robustness is an important consideration for real-world operation. Error propagation to source images induced by noise and inaccuracies in acquired data requires detailed quantification. A technique is currently being explored which uses wavelet basis decomposition of image data coupled with singular-value decomposition for adaptive inversion.

SUMMARY: This effort supports future ship survivability by furthering the evolution of measurement procedures and data processing for ship EM signature characterization. Accurate localization and identification of radiation sources from both scattering (RCS) and emitters is essential for their mitigation in the design, construction and maintenance of future low-observable platforms operating in an increasingly sophisticated enemy sensor environment.

PUBLICATION:

Morgan, M.A., "Electromagnetic Radiation Source Imaging," Project Report No. 3, Office of Naval Research, Code 334, September 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Imaging, Back-Propagation, Diffraction Limit

IMPULSE ANTENNA MODELING

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The goal of this task is to investigate the impulse radiation characteristics of specified antenna structures.

SUMMARY: Initial wire-grid numerical modeling of antenna structures has been completed using frequency-stepping. Impulse source modeling has been approached independently from both frequency- and time-domains to form Thevenin equivalent circuits for impulsive sources. Responses from these distinct source models have been shown to agree. Impulse response characterization of antenna structures is accomplished via inverse transformation of an equivalent circuit.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Impulse Response, Antenna Modeling

PROJECT SUMMARIES

ULTRA-WIDEBAND IMPULSE ANTENNA DESIGN

Michael A. Morgan, Professor

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: The goal of this project was to perform engineering design for efficient, small-sized prototypical ultra-wideband impulse receiving antennas.

SUMMARY: A Method-of-Moments numerical model was developed as an aid to search for optimum geometrical dimensions and resistive tapers to achieve the challenging 10 MHz operation criterion, given the antenna size constraint. Several prototype TEM horns were modeled and performance evaluations conducted. Design specifications were provided to the Army Research Lab for fabrication and testing.

THESIS DIRECTED:

Adamiak, D.V., "Transient Field Visualization for Ultra-Wideband Antenna Design," Master's Thesis, December 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-Wideband, Impulse Antennas, TEM Horns

WIDEBAND LOW-PROFILE COMMUNICATION ANTENNA DESIGN

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Research Office

OBJECTIVE: A finite element algorithm was developed for use in designing omnidirectional wideband VHF communication antennas having low-drag blister type profiles for use on helicopters.

SUMMARY: An analysis tool has been created for use in the design of efficient wideband VHF omnidirectional antennas for employment on Army helicopters. Dielectric loading can be used to optimize impedance matching and antenna pattern over a desired range of frequency. Tapered feed and flare sections, without dielectric loading, provide impedance matching over ultra-wide bandwidths. The finite-element solution uses the coupled-azimuthal potential field formulation with mesh termination by the field-feedback technique. This software tool allows designers to optimize performance while constraining the antenna's physical profile through use of inhomogeneous lossy dielectric loading.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Wideband, Finite Elements, Antenna Design

IMPROVEMENT IN ANTI-SHIP CRUISE MISSILE (ASCM) THREAT SIMULATOR MODELING AND SIMULATION TECHNOLOGY

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The first continuing objective is to develop signal processing routines to improve effectiveness calculations (miss distance) for ship board self-defense systems against incoming anti-ship cruise missiles (ASCM) using hardware-in-the-loop (HIL) simulators. A second continuing objective is to support N91's ASCM Simulator Validation Working Group

PROJECT SUMMARIES

with the development of software routines that automatically extract Electronic Warfare Integrated Reprogrammable Database (EWIRDB) parameters from simulator characterization data obtained in the Naval Research Laboratory (NRL) Central Target Simulator (CTS) anechoic chamber facility.

SUMMARY: A centralized time-space-position information (TSPI) architecture that integrates real-time INS, GPS, and targeting data from captive-carry missile seekers has been developed and the software delivered (Centralized TSPI Software Version 1.0). In this architecture, the local sensors onboard the captive-carry aircraft transmit all recorded data to a centralized algorithm for absolute targeting. Geodetic displays on a Mercator projection provide a complete pictorial presentation of the field test experiment using only the sensors onboard the captive-carry aircraft. That is, the processing is independent of any external range sensors, thereby ensuring all target platforms may participate in the testing without having to contribute positional information to the absolute targeting algorithms. To help support N91's ASCM simulator validation effort, software to extract EWIRDB parameters from the simulator's CTS characterization data was delivered (Automatic Extraction of Threat Simulator Critical Parameters (AETSCP) Version 3.0).

PUBLICATIONS:

Pace, P.E., Nishimura, B.H., Morris, W.M., and Surratt, R.E., "Effectiveness Calculations in Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 34, No. 1, pp. 124-136, January 1998.

Pace, H. and Pace, P.E., "Frequency Management for the 21st Century," *Journal of Electronic Defense*, Vol. 21, No. 1, pp. 21-25, January 1998.

Pace, P.E. and Burton, G.D., "Anti-Ship Cruise Missiles: Technology, Simulation and Ship Self-Defense," *Journal of Electronic Defense*, Vol. 21, No. 11, pp. 51-56, November 1998.

CONFERENCE PRESENTATIONS:

Pace, P.E. and Burton, G.D., "Automatic Extraction of EWIRDB Parameters from Threat Missile Simulators," 66th Military Operations Research Society Symposium, Monterey, CA, 25 June 1998.

Pace, P.E. and Nash, M.D., "A Novel Independent Sensor Fusion Algorithm for Time-Space-Position Information in Captive-Carry Missile Simulator Experiments," 66th Military Operations Research Society Symposium, Monterey, CA, 25 June 1998.

THESES DIRECTED:

Burton, G.D., "Automatic Extraction of Threat Simulator Critical Parameters Version 3.0 (U)," Master's Thesis, Naval Postgraduate School, September 1998.

Nash, M.D., "A Centralized Time-Space-Position Information Architecture for Absolute Targeting in HIL Captive-Carry Missile Simulator Experiments (U)," Master's Thesis, Naval Postgraduate School, September 1998.

Goncalves, W.A., "Computer Modeling of Captive-Carry Missile Simulator Experiments," Master's Thesis, Naval Postgraduate School, September 1998.

OTHER:

Pace, P.E. and Nash, M.D., "Centralized TSPI Software Version 1.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 28 August 1998.

PROJECT SUMMARIES

Pace, P.E. and Burton, G.D., "Automatic Extraction of Threat Simulator Critical Parameters Software Version 3.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 28 August 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Modeling and Simulation

KEYWORDS: Time-Space-Position Information, Captive-Carry, Sensor Fusion, EWIRDB, Hardware-in-the-Loop, Missile Simulation, Effectiveness Calculations

DIGITAL TARGET IMAGING ARCHITECTURES

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Research Laboratory and Naval Postgraduate School

OBJECTIVE: The investigation into the development and testing of several digital target imaging architectures and devices to generate realistic 2.5 ft resolution SAR, ISAR and HRR radar returns is carried out.

SUMMARY: The architectures generate complex imaging and profiling radar returns utilizing modern digital and Digital RF Memory (DRFM) technology. Modeling and simulation techniques were used first to define the required performance parameters and expected imaging results. Using the results of the study, the best architecture was selected and a prototype FPGA was constructed using a NRL 10K50 GPIOP card in order to demonstrate the concept and quantify the amount of resources required for image generation.

CONFERENCE PRESENTATION:

Pace, P.E. and Yeo, S-Y., "Pipelined Digital Image Synthesizers," Technology Cooperation Program, Technical Panel 3 - EW Systems, Naval Postgraduate School, 3 September 1998.

THESIS DIRECTED:

Yeo, S-Y., "A Digital Image Synthesizer for ISAR Counter-Targeting," Master's Thesis, Naval Postgraduate School, September 1998.

PATENT:

Pace, P.E., Surratt, R.E., and Yeo, S-Y., "Radar Image Synthesizer Architecture," Patent Disclosure NC 79,429.

OTHER:

Pace, P.E. and Yeo, S.-Y., "Image Synthesizer Prototype FPGA Design Software Version 1.0," delivered to the Tactical Electronic Warfare Division, Naval Research Laboratory, Washington, DC, 3 September 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Digital RF Memories, FPGA, ISAR, Counter-Targeting

PROJECT SUMMARIES

EXPERIMENTAL INVESTIGATION OF A HIGH-SPEED HIGH-RESOLUTION DIRECTION FINDING ARRAY

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force

OBJECTIVE: To theoretically and experimentally investigate direction finding antenna architectures employing symmetrical number system encoding techniques to provide instantaneous angle of arrival estimates over a wide field of view and wide frequency range.

SUMMARY: A new interferometer direction finding (DF) array architecture based on the optimum symmetrical number system (OSNS) has been examined. OSNS arrays are capable of unambiguous high resolution DF over a wide bandwidth and field of view with as few as three elements, with multiple baseline options. OSNS Acoustic arrays were also investigated as well as symmetrical number system ADC architectures. A three-element DF array was designed, fabricated and tested at 8.5 GHz to verify the OSNS antenna concepts experimentally.

PUBLICATIONS:

Pace, P.E., Styer, D., and Akin, I.A., "A Folding ADC Employing a Robust Symmetrical Number System with Gray-Code Properties," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, TPA14-7, 1 June 1998.

Pace, P.E., Styer, D., and Ringer, W.P., "Optimum SNS-to-Binary Conversion Algorithm and FPGA Realization," *Proceedings of the IEEE International Symposium on Circuits and Systems*, Monterey, CA, TAA14-11, 1 June 1998.

Jenn, D.C. and Pace, P.E., "Symmetrical Number System Phase Sampled Interferometer Direction Finding Antennas," Naval Postgraduate School Technical Report, NPS-EC-98-003, 20 February 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "Symmetrical Number System Phase Sampled DF Antenna Architectures," *Proceedings of the IEEE Antennas and Propagation Society International Symposium*, Atlanta, GA, 21 June 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "High Resolution Wideband Direction Finding Arrays Based on Optimum Symmetrical Number System Encoding," *IEEE Electronics Letters*, Vol. 34, pp. 1062-1064, June 1998.

CONFERENCE PRESENTATIONS:

Pace, P.E., Styer, D., and Akin, I.A., "A Folding ADC Employing a Robust Symmetrical Number System with Gray-Code Properties," *IEEE International Symposium on Circuits and Systems*, Monterey, CA, TPA14-7, 1 June 1998.

Pace, P.E., Styer, D., and Ringer, W.P., "Optimum SNS-to-Binary Conversion Algorithm and FPGA Realization," *IEEE International Symposium on Circuits and Systems*, Monterey, CA, TAA14-11, 1 June 1998.

Jenn, D., Pace, P.E., and Powers, J.P., "High-Resolution Acoustic Arrays Using Optimum Symmetrical-Number-System Processing," *24th International Symposium on Acoustical Imaging*, Santa Barbara, CA, 23 September 1998.

Jenn, D.C., Pace, P.E., Hatzithanasiou, T.N., and Vitale, R., "Symmetrical Number System Phase Sampled DF Antenna Architectures," *IEEE Antennas and Propagation Society International Symposium*, Atlanta, GA, 21 June 1998.

THESIS DIRECTED:

PROJECT SUMMARIES

Hatziathanasiou, T.N., "Optimum Symmetrical Number System Phase Sampled Direction Finding Antenna Architectures," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Symmetrical Number Systems, Phase Sampling Interferometer Arrays, Direction Finding Antennas

METHODS FOR PERFORMANCE ANALYSIS OF HEAT DISSIPATING STRUCTURES

Ron J. Pieper, Visiting Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: Apply techniques based on electrical engineering principles to problems of transient and static heat flow in structures designed for heat dissipation.

SUMMARY: Studies were conducted in three areas: 1) An approximate method of analysis of double stack cold plates based on an assumption that an adiabatic point exists along the structure was proposed, 2) A more general method of analysis of double stack cold plates, which covers all regimes of operation, was developed, and 3) A demonstration that the electronic simulation package PSPICE can be employed to study cold plate structures was reported. In the latter case heat dissipating structures, which would not be, solvable analytically, can be performance evaluated using the methods discussed. This is part of an ongoing effort.

PUBLICATIONS:

Pieper, R.J. and Kraus, A.D., "Design and Analysis of Double Stack Cold Plates Covering All Conditions of Asymmetric Heat Loading," *American Association of Mechanical Engineers (ASME) Journal of Electronic Packaging*, Vol. 120, pp. 296-301, September 1998.

Pieper, R.J. and Kraus, A.D., "Cold Plates with Asymmetric Heat Loading," *International Journal of Microelectronics Packaging*, Vol. 1, pp. 115-129, 1998.

Pieper, R.J. and Michael, S., "Using PSpice to Model the Cooling Performance of Convective Surfaces," *Proceedings of the 30th Southeastern Symposium on System Theory*, pp. 85-89, March 1998.

CONFERENCE PRESENTATION:

Pieper, R.J. and Michael, S., "Using PSpice to Model the Cooling Performance of Convective Surfaces," 30th Southeastern Symposium on System Theory, Morgantown, WV, 11-13 March 1998.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Electronics

KEYWORDS: Electronics, Fin Structures, Modeling

PROJECT SUMMARIES

PHOTONIC SAMPLING ARCHITECTURES FOR MICROWAVE SIGNAL COLLECTION AND ANALYSIS

John P. Powers, Professor

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Secretary of the Air Force and Naval Postgraduate School

OBJECTIVE: This project continues the investigation into photonic sampling of wideband signals using mode-locked lasers and examines the subsequent process of analog-to-digital conversion. It continues an experimental evaluation of an optical sampling fiber laser. Also investigated is the development of optical signal processing architectures for oversampling sigma-delta modulation in order to relax the laser's jitter and optical pulsewidth requirements.

SUMMARY: This research involved the construction of a low-power, sigma mode-locked fiber laser for possible use on mobile signal collection platforms. Measurements were made and algorithms developed in order to quantify the performance characteristics that are important for direct sampling of wideband antenna signals. These include low frequency and high frequency pulse-to-pulse time uncertainty (temporal jitter), amplitude uncertainty (amplitude jitter), pulse repetition frequency, and pulsewidth. The fiber laser demonstrated a PRF of 16 GHz, pulsewidth of 7.2 ps, amplitude noise less than 1%, time jitter of 386 fs and the ability to be harmonically mode-locked at twice the modulation frequency using only 200 mW of diode pump power in the optical amplifier. Also, a novel fiber lattice accumulator design for integrated optical digital antenna technology has been designed. The fiber lattice design uses phase modulation to produce the proper interference between the input optical pulse and the recirculating optical pulse in order that they may be coherently combined. In this manner, the accumulation takes into account the sign of the sampled bipolar antenna signal. The fiber lattice performance has been numerically evaluated within a first-order optical digital antenna phase coherent simulation. The error in antenna performance for several input signals has also been quantified.

PUBLICATIONS:

Butler, J.M., Pace, P.E., and Powers, J.P., "Experimental Results of a Low-Power Sigma Mode-Locked Fiber Laser for Applications in Mobile Sampling of Wideband Antenna Signals," *Proceedings of the 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, to be published 16 February 1999.

Pace, P.E., Bewley, S.A., and Powers, J.P., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," *Proceedings of the 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications*, to be published 16 February 1999.

Pace, P.E. and Powers, J.P., "Photonic Sampling of RF and Microwave Signals," Naval Postgraduate School Technical Report, NPS-EC-98-009, 16 March 1998.

CONFERENCE PRESENTATIONS:

Butler, J.M., Pace, P.E., and Powers, J.P., "Experimental Results of a Low-Power Sigma Mode-Locked Fiber Laser for Applications in Mobile Sampling of Wideband Antenna Signals," 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Santa Barbara, CA, 18 February 1999.

Pace, P.E., Bewley, S.A., and Powers, J.P., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," 9th Annual DARPA Symposium on Photonic Systems for Antenna Applications, Santa Barbara, CA, 19 February 1999.

THESES DIRECTED:

Butler, J.M., "Construction and Measurement of an Actively Mode-Locked Sigma Laser," Master's Thesis, Naval Postgraduate School, June 1998.

PROJECT SUMMARIES

Bewley, S.A., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Digital Antennas," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare, Other (Optics)

KEYWORDS: Mode-Locked Fiber Lasers, Wideband Signal Sampling, Optical Sigma Delta, Fiber Lattice Architectures

AIRPLATFORM SURVIVABILITY ENHANCEMENT

R. Clark Robertson, Professor

Frederick Levien, Senior Lecturer

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Aircraft Division

OBJECTIVE: The objectives for this project are to evaluate the effectiveness of combining countermeasures with low-observable technology, both in the RF and IR domain, to evaluate the effectiveness of an IR-TALD in enhancing air platform survivability, and to investigate the GITSIMS and MOSAIC programs' individual ability to model IR tactical engagement scenarios.

SUMMARY: It is well known through both simulation and field tests that IR flare countermeasures can be effective in reducing the vulnerability of aircraft to incoming IR missile seekers. Smart missiles employing sophisticated CCM (counter-countermeasure) tracking algorithms can reduce or even eliminate the flare's effectiveness. Nonetheless, another gambit for the aircraft designer is the employment of designs which would either reduce IR signature or redistribute the power in the IR signature to make the aircraft less vulnerable. This parametric study demonstrates the level of synergism between the employment of both decoy flares and the employment of stealthy IR reduction methods. The effects of IR signature reduction for a large number of one-on-one simulation engagements using MOSAIC have been completed. Preliminary results indicate that IR signature reduction does not significantly increase the effectiveness of IR flares.

CONFERENCE PRESENTATIONS:

Copeland, B., Pieper, R., Robertson, C., Levien, F., and Buczynski, P., "IR-Signature Dependent Effectiveness of Flare Countermeasures," to be presented at the Advanced Technology Electronic Defense Systems (ATEDS) 1999 Symposium, Monterey, CA, 16-18 March 1999.

Alvarado, L., Robertson, C., and Levien, F., "A Methodology for Conducting a Cost Effectiveness Analysis Study of the Integration of Low Observables and Electronic Warfare in Air Vehicle Design," to be presented at the Advanced Technology Electronic Defense Systems (ATEDS) 1999 Symposium, Monterey, CA, 16-18 March 1999.

THESIS DIRECTED:

Alvarado, O.L., "Determination of a Methodology for Conducting a Cost Effectiveness Analysis Study of the Integration of Low Observables (LO) in Electronic Warfare (EW) in Air Vehicles (AV) Design," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY: Electronic Warfare

KEYWORDS: Electronic Countermeasures, IR Countermeasures, Low-Observable Technology

PROJECT SUMMARIES

FAST FREQUENCY-HOPPED DIGITAL COMMUNICATION

R. Clark Robertson, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of this project is to determine the electronic counter-countermeasures (ECCM) potential of fast frequency-hopped (FFH), noncoherent M-ary frequency-shift keyed (MFSK) and FFH differential phase-shift keyed (DPSK) communication systems over super high frequency (SHF) and extremely high frequency (EHF) satellite communication links under conditions of worst case hostile electronic countermeasures (ECM) and fading channels.

SUMMARY: The performance degradation resulting from both partial-band barrage noise interference and multi-tone interference of orthogonal, noncoherent frequency-hopped, M-ary frequency-shift keyed receivers (FH/MFSK) was investigated. Extension of the results to FH/DPSK was trivial. The effect of thermal and other wideband noise was not neglected. Furthermore, the channel was modeled as a Ricean fading channel, and both the information signal and the interference signal were assumed to be affected by channel fading. Both band and independent multitone interference were considered. Performance was evaluated by obtaining a union bound on the probability of bit error, and receiver performance was compared with exact results for band multitone interference of a noncoherent FH/MFSK receiver under comparable circumstances. Except for the case of Rayleigh fading of the signal, the union bound was very tight for those cases that can be compared with exact results. The advantages of the union bound approach were twofold. First, the union bound approach yielded a solution that is far less computationally intensive than that obtained with the exact approach. Second, the union bound approach allowed numerical results to be obtained for interference conditions that were not amenable to exact analysis, such as independent multitone interference of FH/MFSK. When rate convolutional coding with Viterbi was used, contrary to conventional wisdom, performance was superior with hard decision decoding as opposed to soft decision decoding when partial-band noise jamming was present.

PUBLICATION:

Tedesso, T.W. and Robertson, R.C., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding in the Presence of Partial-Band Noise Jamming," *Proceedings of the IEEE Military Communications Conference*, Vol. 2, pp. 484-488, 1998.

CONFERENCE PRESENTATION:

Tedesso, T.W. and Robertson, R.C., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding in the Presence of Partial-Band Noise Jamming," 1998 IEEE Military Communications Conference, Boston, MA, 18-21 October 1998.

THESIS DIRECTED:

Tedesso, T.W., "Performance Analysis of a SFH/NCBFSK Communication System with Rate Convolutional Coding and Soft Detection Viterbi Detection Over a Ricean Fading Channel with Partial-Band Noise Jamming," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Spread Spectrum, Frequency-Hopping, Partial-Band Jamming

PROJECT SUMMARIES

GEOLOCATION IMPROVEMENTS AT LOW LATITUDES

Rasler W. Smith, Research Assistant Professor

Richard W. Adler, Research Associate Professor

Gus K. Lott, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To determine temporal and spatial extent of ionospherically induced radiowave scintillation in the equatorial region and ascertain the deleterious effects of the scintillation on geolocation.

SUMMARY: The experiment observed equatorial-region ionosphere total electron content (TEC) derived from Global Positioning System (GPS) signals using receivers on Oahu, Christmas Island, and Rarotonga. VHF transequatorial propagation from Hawaii to Rarotonga was simultaneously measured. Analysis showed that a moving second moment of vertical-equivalent TEC strongly correlates to each VHF transequatorial radio propagation event. The research also develops equations that show the potential errors in time, frequency, and angle used in geopositioning solutions.

PUBLICATION:

Smith, R.W., Adler, R.W., and Lott, G.K., "Scintillation Prediction and Geolocation at Low Latitudes," Naval Postgraduate School Technical Report, NPS-EC-98-007, March 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Geolocation, Scintillation

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

Department of Electrical and Computer Engineering

Sponsor: Advanced Maritime Projects Office

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and related processing, time-domain analysis, and data fusion for Beartrap post-mission analysis.

SUMMARY: The system is being developed based on commercial off the shelf technology: PentiumPro-based PC with Windows NT operating system. The user interface is being developed using Microsoft Visual C++; all processing algorithms are being coded in the C++ language as well.

During 1998, several new user interface screens have been designed. Software for reading data from analog tape has been completed and interfaced to the hardware. An algorithm for expanding narrowband lines and viewing these with high resolution was implemented and a set of various graphical analysis tools and views were implemented and brought into the system. Work on the target tracker continued and is near completion.

THESES DIRECTED:

Kohl, C.A., "Development of a Narrowband Zoom Processing Capability Using Commercial Processors," Master's Thesis, Naval Postgraduate School, June 1998.

Minyard, J.D., "Development of Analysis Tools and Incorporation of Commercial Digital Signal Processors in a Signal Analysis Graphical User Interface," Master's Thesis, Naval Postgraduate School, June 1998.

PROJECT SUMMARIES

OTHER:

The research is producing software for delivery to the sponsor. A pre-beta version of the software has already been delivered. A demonstration of the current software was conducted at the November 1998 meeting of the Beartrap mission specialists.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Other (Signal Processing)

KEYWORDS: Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

MULTI-SENSOR DATA FUSION FOR THE VESSEL TRAFFIC SERVICES SYSTEM

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

OBJECTIVE: To develop data fusion algorithms based on fuzzy association techniques for use in the USCG vessel traffic system upgrade project.

SUMMARY: Vessel Traffic System (VTS) receives data from multiple sensors of different types: multiples radars, differential global positioning system based ADS receivers, acoustic sensors, and synthetically generated standard routes. Multiple sensors tracking the same target generate a large amount of redundant data. Here we have developed a data association algorithm based on fuzzy clustering-mean approach to fuse data from multiple sensors. The algorithm is being tested using field-recorded data (from Puget Sound, WA).

PUBLICATIONS:

Aziz, A., Tummala, M., and Cristi, R., "A Time Series of Decisions Approach in Detection Systems," *Proceedings of 32nd Asilomar Conference on Signals, Systems, and Computers*, 1-4 November 1998.

Aziz, A., Tummala, M., and Cristi, R., "Fuzzy Logic Data Association Approach in Multisensor Multitarget Data Fusion," *Proceedings of IASTED International Conference on Signal and Image Processing*, 28-31 October 1998.

Midwood, S., Glenn, I., and Tummala, M., "Multisensor Data Fusion Algorithm for the USCG's Vessel Traffic Services," *Proceedings of 1998 IEEE International Conference on Circuits and Systems*, June 1998.

Aziz, A., Tummala, M., and Cristi, R., "Fuzzy Logic Data Correlation Approach in Multisensor-Multitarget Tracking Systems," accepted for publication, *Journal of Signal Processing*, July 1999.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors

KEYWORDS: Data Fusion, Fuzzy Logic, Multiple Sensors

PROJECT SUMMARIES

PHASE ADJUSTMENT CONTROL FOR LORAN-C APPLICATIONS

Murali Tummala, Professor

Roberto Cristi, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Coast Guard

OBJECTIVE: To develop algorithms for estimation and control of time difference error in LORAN-C receivers to replace the existing CALOC system.

SUMMARY: This work is part of Coast Guard's Loran-C re-engineering effort, both transmitter and receiver units. A stochastic model has been investigated, which accommodates short term (on the order of seconds) as well as long-term (on the order of hours) influences of disturbances. A multiresolution Kalman filter algorithm will be used to evaluate the effectiveness of the model.

PUBLICATION:

Cristi, R., Tummala, M., and France, F.M., "Algorithms for LORAN-C Time Difference Error Minimization," Naval Postgraduate School Technical Report, NPS-EC-98-002, January 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Time Difference Error, Stochastic Model, Kalman Filter

TRAFFIC CHARACTERIZATION AND SCHEDULING ISSUES IN MULTIMEDIA WIRELESS NETWORKS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To develop traffic models for multimedia information and algorithms for scheduling of such traffic over wireless networks.

SUMMARY: In this effort, we developed traffic models for low bit rate video. Also extensively studied the scheduling of multimedia traffic cells over a wireless ATM network. This work is of interest to Code D8805, Communications and Information Systems Department, SPAWAR Systems Center, San Diego.

PUBLICATION:

Parker, R.E. and Tummala, M., "Modeling of H.263 Encoded Low-Bit-Rate Video Traffic for Tactical Video Conferencing Applications," *Proceedings of 32nd Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, 1-4 November 1998.

DISSERTATION DIRECTED:

Uziel, A., "Channel Allocation in Wireless Integrated Services Networks for Low-Bit-Rate Applications," Doctor of Philosophy Dissertation, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Wireless Communication Networks, Asynchronous Transfer Mode, Integrated Services Digital Networks, Video Traffic, Video Teleconferencing

PROJECT SUMMARIES

RELOCATABLE REGIONAL SATELLITE-BASED TACTICAL MOBILE TELEPHONE NETWORK

Don Wadsworth, Senior Lecturer
Department of Electrical and Computer Engineering
Sponsor: Naval Space Command

OBJECTIVE: Provide planning/decision guidance for meeting future tactical, assured-access, narrowband communications surge requirements in regional operations. The proposed system(s) would supplement the very limited surge capacity of existing/planned assets based on fixed-location satellite constellations (e.g., UFO, DSCS, Milstar). This is a continuing project.

SUMMARY: This is an interim report since this project will not be completed until 30 June 1999 when the students involved in the research have completed their thesis research. Studies are being conducted in several areas: 1) mobile user requirements definition, 2) large antenna design, 3) waveform, 4) link budget, and 5) on-orbit thruster design. Part of the research is classified at the TS/SCI level and cannot be included here.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MILSATCOM, Mobile Satellite Service (MSS), Surge

SINGLE EVENT UPSET (SEU) IMMUNE LOW TEMPERATURE GROWN GaAs INTEGRATED CIRCUITS

Todd Weatherford, Assistant Professor
Douglas Fouts, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To harden digital gallium arsenide (GaAs) integrated circuits to space radiation by re-engineering the initial semiconductor wafer.

SUMMARY: The program has developed GaAs semiconductor wafers, which provide radiation hardness to single event upsets (or soft errors), induced by cosmic radiation. A buried low temperature grown Gallium Arsenide (LT GaAs) buffer layer epitaxy is grown on a GaAs wafer. The wafer is substituted in commercial GaAs foundries to provide radiation hardened integrated circuits. The buffer layer increases recombination to eliminate excess carriers produced from ionizing radiation. The last year of this program has investigated improving the stability of the LT GaAs buffer layer for semiconductor manufacturing, and performing radiation experiments. Work in 1998 improved performance of the Motorola GaAs process by 20%, and showed that processing temperatures up to 700°C can be tolerated without compromising transistor parameters.

PUBLICATION:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," *Proceedings of the 1998 EIA/IEEE GaAs Reliability Workshop*, Atlanta, GA, November 1998.

CONFERENCE PRESENTATION:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M.,

PROJECT SUMMARIES

Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," 1998 EIA/IEEE GaAs Reliability Workshop, Atlanta, GA, November 1998.

THESES DIRECTED:

Devers, J., "Frequency Dependence of Single Event Upsets in Gallium Arsenide Metal Semiconductor Field Effect Transistors," Master's Thesis, Naval Postgraduate School, June 1998.

Mason, C., "Characterization of Heterojunction Insulated Gate Field Effect Transistors," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Materials, Processes, and Structures, Manufacturing Science and Technology, Modeling and Simulation

KEYWORDS: Gallium Arsenide, Radiation Effects, Semiconductors

RADIATION HARDNESS ANALYSIS OF InP AND SiGe TECHNOLOGIES FOR SPACE APPLICATIONS

Todd Weatherford, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Secretary of the Air Force

OBJECTIVE: To investigate the radiation hardness of InP and SiGe state-of-the-art electronic technologies for use in military space environments.

SUMMARY: Experiments utilized femto-second lasers with photo-conductive sampling probes to measure the first recorded radiation induced in-situ voltage transients internal to an integrated circuit operating at 10 GHz. Facilities at the University of Michigan's Center of Ultrafast Science were utilized for the laser experiments and computer modeling of the underlying charge transport mechanisms were performed at NPS. The 1998 research examined studied the Hughes Research Laboratories InP-based Heterojunction bipolar processes. Test structures in IBM's SiGe process were designed and fabricated and are to be tested in 1999.

PUBLICATIONS:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," *Proceedings of the 1998 EIA/IEEE GaAs Reliability Workshop*, Atlanta, GA, November 1998.

David, G., Yun, T., Crites, M., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "Absolute Potential Measurements Inside Microwave Digital ICs Using a Micromachined Photoconductive Sampling Probe," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 46, No. 12, December 1998.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., Yun, T., Crites, M., Meyer, S., Bustamante, M., Thomas, S., III, and Elliott, K., "Measurements of Laser Induced SEE Voltage Transients in InP HBT Logic," *Proceedings of the 11th Annual Single Event Effects Symposium*, Manhattan Beach, CA, 23 April 1998.

David, G., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "DC-to-mm-Wave Absolute Potential Measurements Inside Digital Microwave ICs Using a Micromachined Photoconductive Sampling Probe," *IEEE MTT-S International Microwave Symposium Digest 1998*, New York: IEEE, pp. 1333-1336, 1998.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Weatherford, T.R., David, G., Yun, T., Crites, M., Whitaker, J.F., Jobe, K., Ledbetter, E.J., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "In-situ Picosecond Measurements of InP and GaAs ICs Utilizing Photoconductive Sampling Probes," 1998 EIA/IEEE GaAs Reliability Workshop, Atlanta, GA, November 1998.

David, G., Yun, T., Crites, M., Whitaker, J.F., Weatherford, T.R., Jobe, K., Meyer, S., Bustamante, M., Goyette, W., Thomas, S., III, and Elliott, K., "Absolute Potential Measurements Inside Microwave Digital ICs Using a Micromachined Photoconductive Sampling Probe," IEEE International Symposium on Microwave Technology, Baltimore, MD, June 1998.

Weatherford, T.R., David, G., Whitaker, J., Jobe, K., Yun, T., Crites, M., Meyer, S., Bustamante, M., Thomas, S., III, and Elliott, K., "Measurements of Laser Induced SEE Voltage Transients in InP HBT Logic," 11th Annual Single Event Effects Symposium, Los Angeles, CA, April 1998.

THESES DIRECTED:

Cochran, F., "Single Event Analysis of AlInAs/GaInAs/InP Heterojunction Bipolar Transistors," Master's Thesis, Naval Postgraduate School, June 1998.

Mayfield, T., "Characterization of InGaAs/AlInAs Heterojunction Bipolar Transistors," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures, Modeling and Simulation

KEYWORDS: Radiation Effects, Indium Phosphide, Gallium Arsenide

TIME RESOLVED SINGLE EVENT EFFECT STUDIES IN SILICON ON INSULATOR (SOI)

Todd Weatherford, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Air Force Research Laboratory

OBJECTIVE: To measure single event transients in very high speed digital circuits fabricated with silicon on insulator (SOI) technologies with ion and laser facilities. The picosecond transients will be compared to circuit and device simulations.

SUMMARY: The program will start to examining SOI circuits fabricated in MIT Lincoln Laboratory's 0.25 μm and 0.11 μm semiconductor process in early 1999. We expect to expand these measurements to SPAWAR's SOI process. Circuits provided by MIT/LL with additional circuits designed by NPS will be studied at two facilities: a) University of Michigan's Center for Ultrafast Science utilizing their in-situ photoconductive probe and lasers and b) the Sandia Microbeam facility for examine heavy ion induced transients. Both facilities can ionize charge in sub-micron diameter tracks by utilizing < 5 μm optical fibers or ion beams with apertures < 3 μm . The purpose is to determine the similarities and differences for using a laser to simulate heavy ion induced transients, and also to determine if the external measurement capabilities of the Sandia system are as accurate in comparison to the Michigan system. Students will assist in modeling the mechanisms for these transients in Technology Computer Aided Design (TCAD) and in performing the experiments.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Space Vehicles

KEYWORDS: Silicon-On-Insulator, Single Event Upsets, Picosecond Transients

PROJECT SUMMARIES

LOW-BAND HARM ASSESSMENTS AND EVALUATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: To provide initial analysis and assessments of low-band HARM Guidance System architectures and designs and enabling technologies and products.

SUMMARY: The HARM missile guidance section provides basic band HARM system concept is a next step in the evolution of HARM missile development. At low frequencies, unique and application specific signals and potential unintentional signals exist, which have not been exploited for HARM applications. The HARM missile can be improved by exploiting these new signal opportunities.

DoD KEY TECHNOLOGY AREAS: Sensors, Missiles, Guidance, Targeting

KEYWORDS: Guidance System, RF Receiver, Video Processor, Signal Extraction, Parameter Extraction, Low-Band, Antenna

ECONOMICAL SAR/ISAR SYSTEM DEVELOPMENT FOR UNMANNED AERIAL VEHICLE (UAV) APPLICATIONS – PHASE ONE

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Office of Naval Research

OBJECTIVE: To develop new innovative and economical SAR/ISAR techniques for potential UAV applications. Emphasis is on using new SAR/ISAR waveforms and new concept SAR/ISAR processing techniques.

SUMMARY: SAR/ISAR sensors are key surveillance and targeting assets for Navy airborne missions. High resolution and high fidelity SAR images are required to meet surveillance and target detection requirements. Without these long-range SAR sensors, our key warfare information and military response capabilities are severely restricted for modern warfare scenarios and even peacetime missions.

The proposed Virtual-Aperture MTI/SAR/ISAR concept provides SAR surface target mapping, ISAR ship-target detected moving targets on SAR maps. This new SAR concept uses economical COTS products for generating moderate instantaneous bandwidth waveforms, digital sampling with low-speed A/D converters and signal processing with relatively low-speed DSPs.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Radar, Surveillance, Targeting)

KEYWORDS: SAR, ISAR, DSP, Hopped-Frequency, Chirped, MTI, Virtual Aperture Processing

WIRELESS DAMAGE CONTROL COMPUTER NETWORKS

Xiaoping Yun, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: To investigate the feasibility of deploying a wireless computer network aboard submarines for damage control communications.

PROJECT SUMMARIES

SUMMARY: The effect of a mostly metallic submarine environment on wireless communications and mitigating methods were examined. The overall requirements and specifications for a submarine wireless network were derived. These requirements were then matched against capabilities of existing commercial products in the mobile computing and wireless networking industries. A proof of concept system was developed and evaluated in both laboratory and submarine environments. Testing results demonstrated that a low-cost, high-performance wireless local area network for use in submarines was achievable using existing technologies.

THESIS DIRECTED:

Debus, S.M., "Feasibility Analysis for a Submarine Wireless Computer Network Using Commercial-Off-the-Shelf Components," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Damage Control, Wireless Computer Networks

ACCURATE CONTROL OF MANIPULATORS USING INERTIAL SENSORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Science Foundation

OBJECTIVE: To investigate control and coordination of robot manipulators using inertial sensors.

SUMMARY: A small INS/GPS navigation system (SANS) was developed and tested. It consisted of a low-cost small-size inertial measurement unit (IMU), a DGPS, and TCM-2 digital compass. Data were collected and processed by an AMD 586DX133 based PC/104 computer. Estimation software was based on an asynchronous Kalman filter. This sensor system and a Zebra-Zero 6-DOF manipulator were mounted on a moving platform. Testing results demonstrated that the manipulator mounted on a moving platform was able to compensate for random platform motions and successfully perform various manipulation tasks.

PUBLICATION:

Yun, X., Hernandez, G.C., Bachmann, E.R., McGhee, R.B., and Healey, A., "An Integrated GPS/INS Navigation System for Small AUVs Using an Asynchronous Kalman Filter," *Proceedings of 1998 IEEE Symposium on Autonomous Underwater Vehicle Technology (AUV '98)*, Draper Laboratory, Cambridge, MA, 20-21 August 1998.

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Hernandez, G.C., "An Integrated GPS/INS Navigation System for Small AUVs Using an Asynchronous Kalman Filter," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: INS, GPS, AUV, Navigation, Kalman Filter

PROJECT SUMMARIES

TRACTION CONTROL OF AUTONOMOUS ALL-TERRAIN ROBOTIC VEHICLES

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this project is to investigate traction control of the Shepherd mobile robot.

SUMMARY: Shepherd is a four-wheel-drive and four-wheel-steer autonomous ground vehicle developed at NPS for land mine search purposes. When the vehicle travels on off-road surfaces, its traction can be improved by monitoring the percentage of slip of each wheel and by actively adjusting driving torques distributed to four wheels. This project studied estimation methods for determining the amount of wheel slip and active traction control algorithms for improving the vehicle's maneuverability on rough terrains. A traction control algorithm was developed for intelligently distributing driving torques among different wheels of a robotic vehicle based on the amount of wheel slip. A comprehensive simulation study on the effectiveness of the traction control algorithm was conducted. An inertial navigation system was integrated and tested on the Shepherd mobile robot.

PUBLICATIONS:

Sarkar, N. and Yun, X., "Traction Control of Wheeled Vehicles Using Dynamic Feedback Approach," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '98)*, pp. 413-418, Victoria, Canada, 13-17 October 1998.

Yun, X., Latt, K., and Glennon, J.S., "Mobile Robot Localization Using the Hough Transform and Neural Network," *Proceedings of the 1998 IEEE ISIC/CIRA/ISAS Joint Conference on the Science and Technology of Intelligent Systems*, pp. 393-400, Gaithersburg, MD, 14-17 September 1998.

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THESES DIRECTED:

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Glennon, J.S., "Feature-Based Localization of Mobile Robots Through Hough Transform and Unsupervised Learning Network," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Other (Robotic Technology)

KEYWORDS: Traction Control, Autonomous Vehicles

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1998 THESIS ABSTRACTS

DETERMINATION OF A METHODOLOGY FOR CONDUCTING A COST EFFECTIVENESS ANALYSIS STUDY OF THE INTEGRATION OF LOW OBSERVABLES (LO) AND ELECTRONIC WARFARE (EW) IN AIR VEHICLE (AV) DESIGN (U)

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The advent of decreasing defense budgets coupled with acquisition reform efforts and the high cost of advanced technology applications has produced a definitive need for a methodology to assess the cost benefit of aircraft performance specifications. This methodology must be an iterative process that allows the user to perform design tradeoffs and assess their respective impacts to military utility and cost. This thesis details the approach for conducting an Analysis of Alternatives (AoA), a.k.a. Cost and Operational Effectiveness Analysis (COEA), study to assess the cost-performance tradeoffs of applying Low Observable (LO) technology and Electronic Warfare (EW), either exclusively or mutually, to an aircraft design. The methodology recommends the use of engagement level models and simulations (M&S) coupled with mission level M&S in the absence of a single integrated M&S product. The engagement level analysis is necessary to support high fidelity data requirements that are used by the mission level program to gather relevant measures of effectiveness (MOE) required for the mission effectiveness evaluation. These MOE's are then integrated with corresponding cost data in an effort to examine cost-performance characteristics. Iterative performance modifications can be similarly evaluated in an effort to establish trends, which will assist the user in assessing cost-performance tradeoffs.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Low Observables, Electronic Warfare, Electronic Counter-Measures)

KEYWORDS: Low Observables, Radar Cross Section Reduction, RCS, Electronic Counter-Measures, ECM, Modeling and Simulation, M&S, Mission Level Modeling and Simulation, Enhanced Surface-To-Air Missile Simulation, ESAMS

THE ANALYSIS OF COMPONENTS, DESIGNS, AND OPERATION FOR ELECTRIC PROPULSION AND INTEGRATED ELECTRICAL SYSTEM

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The surface combatant of the 21st century will be designed to support a myriad of tasks requiring greater flexibility and endurance while keeping construction, maintenance and operating costs to a minimum. As a result the design of a surface combatant will depart from today's standards and philosophies. One option is the use of an electric propulsion system that can be integrated with the other ship's electrical loads. Electric propulsion operating with an Integrated Electrical System has many advantages that will fulfill the requirements of future surface combatants.

This study provides the historical background, the supporting issues, components, and architecture of electric propulsion systems and the integrated electrical system. Technical information on various component types and issues that influence the design considerations of an electric propulsion system and integrated electrical system to meet the requirements of a surface combatant are addressed. The areas of study are prime movers, generators, frequency converters, motors, ship's service electrical distribution, auxiliary electrical loads, and system control.

The designer and operator of the surface combatant of the 21st Century can better understand the application of an electric propulsion system and an integrated electrical system from the accrued information on components, system architecture, and system control herein.

1998 THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Electric Propulsion, Ship's Propulsion, Prime Movers, Generators, Synchroconverter, Cycloconverter, Pulse Width Modulation, Synchronous Motors, Synchronous Machine Ship's Service Electrical System, Integrated Electrical System, Ship's Service Distribution System, Ship's Service Electric Generator, Six-Pulse, 12-Pulse, DC ZEDS, Electro-Magnetic Aircraft Launching System, Pulse Energy Weapons, Power Electronic Devices

GLOBAL BROADCAST SYSTEM REACH BACK VIA ULTRA HIGH FREQUENCY DEMAND ASSIGNED MULTIPLE ACCESS SATELLITE COMMUNICATIONS

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Roy Axford, Space and Naval Warfare Systems Center-San Diego

The U.S. military requires a reliable, high-speed, multimedia capable system to disseminate information that cannot be efficiently distributed over existing low data rate channels. The Global Broadcast System (GBS) is being developed to meet this requirement. The cornerstones of the GBS simplex broadcast are the premises of smart push and user pull. An integral part of the user pull is the reach back channel. The reach back channel allows users to specify the information they need broadcast and tailor the information to meet their mission needs. Ultra high frequency (UHF) demand assigned multiple access (DAMA) satellite communications are the most widely available long haul communication systems available to members of the armed services and as such are a prime candidate to provide a reach back path for GBS. In order to fully utilize UHF DAMA as a reach back channel for data communications a number of interface requirements must be met. The problems of using UHF DAMA are discussed and recommendations are made for the GBS Phase Two systems so they might support the use of UHF DAMA as a reach back channel. This thesis shows that UHF DAMA is a viable reach back channel, however there are factors which could improve the efficiency.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Global Broadcast System, Reach Back, Ultra High Frequency Demand Assigned Multiple Access

DESIGN OF AN 8 x 8 NON-BLOCKING CROSSPOINT SWITCH IN GaAs TWO-PHASE DYNAMIC FET LOGIC

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Second Reader: Sherif Michael, Department of Electrical and Computer Engineering

Computer resources on military and telecommunications satellites are being over-tasked more than ever before, and the increasing shift to onboard signal processing will only compound the problem in the future. Space-based multiprocessor computer systems linked by high speed interconnect networks offer one possible solution to this ever-expanding problem. Gallium arsenide (GaAs) integrated circuits using metal-semiconductor field effect transistors (MESFETs) offer very high speed operations, reduced power consumption, and inherent radiation tolerance, which make them ideally suited to the harsh space environment.

The design, simulation and layout of an 8 x 8 non-blocking crosspoint switch implemented in GaAs two-phase dynamic FET logic (TDFL) is presented in this thesis. The design of the TDFL crosspoint switch design that uses GaAs direct-coupled FET logic (DCFL). Design specifics of working with GaAs are presented first, followed by detailed descriptions of the DCFL and TDFL crosspoint switches, and finally, an analysis of the advantages and disadvantages of dynamic logic over static logic is presented.

1998 THESIS ABSTRACTS

The TDFL crosspoint switch presented here could easily be modified to serve as a one gigabit per second serial interconnect for future space-based multiprocessor computer systems.

KEYWORDS: GaAs, Gallium Arsenide, Crosspoint Switch, TDFL, Two-phase Dynamic FET Logic

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Command, Control, and Communications

TRANSIENT LOCALIZATION IN SHALLOW WATER ENVIRONMENTS

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Master of Science in Engineering Acoustics-March 1998

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In this work, the robustness of a simple, Bartlett-type processor based on matching broadband signal autocorrelation functions is investigated. Measures of robustness to be examined include the size of the localization footprint on the ambiguity surface and the peak-to-sidelobe levels in the presence of environmental mismatch and noise. A full-wave PE model is used to produce broadband replicas. Both model-generated synthetic signals, which provide baseline results, and measured pulses in a shallow water environment are analyzed.

This work suggests that environmental mismatch has a more significant effect on the localization performance than noise. It also suggests that, as long as the noise level is not higher than the signal level, the localization performance will not be significantly affected. This is to be expected, since for white noise the majority of the influence on the autocorrelation function occurs at zero lag which has been removed in the localization algorithms. It is also shown that the autocorrelation matching in the time-domain is generally more useful for smaller bandwidths at low frequencies, which has been observed in previous work, whereas the autocorrelation matching in the frequency-domain is better suited for larger bandwidths and higher frequencies.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Autocorrelation Matching, Transient Localization, Shallow Water

MERGEFORMAT AUTOMATIC EXTRACTION OF THREAT SIMULATOR

CRITICAL PARAMETERS VERSION 3.0 (U)

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Second Reader: Don Kahl, Naval Research Laboratory

Anti-ship cruise missiles (ASCMs) continue to be a poignant threat to the surface combatants of the U.S. Navy. OPNAV 913 directs the Effectiveness of Navy Electronic Warfare Systems (ENEWS) program to develop hardware-in-the-loop (HIL) simulators to support the research, development, test and evaluation of the most critical threats of interest. To ensure that the ASCM simulator accurately represents the threat missile, OPNAV 913 has recently established the Navy Unique ASCM Simulator Validation Working Group. One part of the validation process is to run the ASCM simulator through a battery of anechoic chamber characterization tests in order to determine the simulator's performance. The ASCM simulator's Electronic Warfare Integrated Reprogrammable Database (EWIRDB) parameters can easily be extracted from the characterization results using computer algorithms that automatically analyze the data. Comparing the corresponding parameters with the EWIRDB intelligence entries then provides one technique for measuring the performance of the ASCM simulator. This thesis describes a novel set of algorithms that extract 32 new EWIRDB parameters from characterization data, of

1998 THESIS ABSTRACTS

which 29 are related to pulse repetition interval (PRI) characteristics, two are related to velocity memory and one is related to azimuth accuracy. FFT and autocorrelation function techniques to compute PRI mode parameters with periodic and staggered components are developed. Also, a graphical user interface (GUI) in a Matlab environment and a modular architecture allowing for straightforward software development and maintenance are discussed. The performance of a number of significant threats are numerically evaluated as a function of the test results.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Modeling and Simulation, Computing and Software

KEYWORDS: ASCM Simulators, Automatic Extraction of Threat Simulator Critical Parameters, GUI, Algorithms, EWIRDB Parameters

CONSTRUCTION AND MEASUREMENT OF AN ACTIVELY MODE-LOCKED SIGMA LASER

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The direct digitization of microwave signals of interest would allow rapid computer processing and analysis. Current analog-to-digital converters (ADCs) are bandwidth limited and electronic warfare systems must down-convert the signal before digitization causing a loss of information. Optical ADCs can directly digitize frequencies greater than 10 GHz using wideband integrated optical interferometers (folding ADCs). A critical component of the optical folding ADC is the pulsed laser used for sampling the wideband signal. The amplitude-modulated pulses become the discrete samples of the analog signal. Limiting factors in an optical ADC are the pulsewidth, the pulse rate, and the jitter noise of the optical pulse train. Mode-locked lasers provide pulse rates and pulsewidths suitable for high bandwidth applications.

In this thesis a mode-locked sigma laser was constructed using fiber-optic, electro-optic, and microwave components. The theory of mode-locking, laser construction, output measurements, and sampling applications are discussed in detail. The mode-locked sigma laser demonstrated a pulse repetition frequency of 16 GHz, pulsewidth of 7.2 picoseconds, amplitude noise less than 1%, temporal jitter of 386 femtoseconds, and the ability to be harmonically mode-locked at twice the modulation frequency using only 200 mW of diode pump power in the optical amplifier. The analysis shows that this laser can be used in an optical ADC to sample a 6.44 GHz signal at 7 bits, 3.22 GHz at 8 bits, or 1.61 GHz at 9 bits of resolution.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Other (Photonics)

KEYWORDS: Mode-Locked Laser, Sigma Laser, Erbium-Doped Fiber Amplifier, Optical Sampling, Analog-to-Digital Conversion, Amplitude Noise, Phase Noise, Temporal Jitter Noise, Timing Uncertainty

DENOISING OF ACOUSTIC SIGNALS USING WAVELET/WIENER BASED TECHNIQUES

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Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

This thesis investigates the use of combined Wavelet decomposition and Wiener filtering for the removal of noise from underwater acoustic signals. Several Wavelet/Wiener based denoising techniques are presented and their performances

1998 THESIS ABSTRACTS

compared. Performances of the denoising algorithms are compared to those of Wiener filter and wavelet thresholding implementation and demonstrate that Wavelet/Wiener based methods are also a viable tool for the denoising of acoustic data under more restrictive conditions.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Acoustic Signals, Wavelets, Wiener Filter, Denoising, Aliasing

SINGLE-FREQUENCY MEASUREMENTS USING UNDERSAMPLING METHODS

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Master of Science in Electrical Engineering-March 1998

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Second Reader: Curtis D. Schleher, Information Warfare Academic Group

The objective of this study is to verify the Symmetrical Number System (SNS) undersampling receiver architecture using software and to investigate implementation issues using digital signal processing (DSP) hardware. In the software design, a MATLAB program is written to determine a single sinusoidal input frequency using this receiver architecture. Each channel of the SNS undersampling receiver consists of a low speed ADC, a discrete Fourier transform followed by a constant threshold device to detect the signal's frequency bin. The detected frequency bins are then recombined in an SNS-to-decimal algorithm to recover the frequency of the signal. Error rate performance in a Gaussian noise environment at the input stage is evaluated. In the hardware design, a sinusoidal waveform is digitized, discrete Fourier transformed and converted from the SNS format to a decimal value using a single channel digital signal processor. Implementation difficulties and design issues are discussed.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Symmetrical Number System, Symmetrical Folding, Undersampling, Discrete Fourier Transform

ARCHITECTURAL DEVELOPMENT AND PERFORMANCE ANALYSIS OF A PRIMARY DATA CACHE WITH READ MISS ADDRESS PREDICTION CAPABILITY

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This work is part of an ongoing effort to bridge the cycle-time gap between high-speed processing units and lower-speed main memories through the use of memory hierarchies. Cache memory exploits the principle of locality by providing a small, fast memory between the processor and the main memory. The Predictive Read Cache (PRC) further improves the overall memory hierarchy performance by tracking the data read miss patterns of memory accesses, developing a prediction for the next access and prefetching the data into the faster cache memory. The PRC has been proven to significantly improve system performance when acting as a second-level cache. The purpose of this thesis is to simulate the effectiveness of the PRC as a first-level cache in the memory hierarchy using the same simulator developed to prove the effectiveness of the PRC as a second-level cache.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Predictive Read Cache, Address Prediction, Memory Bandwidth, Memory Latency, Cache Memory, Memory Systems

1998 THESIS ABSTRACTS

SINGLE-EVENT ANALYSIS OF AlInAs/GaInAs/InP HETEROJUNCTION BIPOLAR TRANSISTORS

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**M.A., Troy State University at Montgomery, December 1995
Master of Science in Electrical Engineering-June 1998**

**Advisor: Todd R. Weatherford, Department of Electrical and Computer Engineering
Second Reader: Douglas J. Fouts, Department of Electrical and Computer Engineering**

For many of today's spaceflight programs, spacecraft and spacecraft designers are being pushed to utilize enabling and emerging technology in order to meet performance constraints in small-volume and low-power, low-cost spacecraft. These newer technologies must be evaluated to meet the performance requirements of spacecraft, especially for the smaller, low-cost satellite programs. AlInAs/GaInAs heterojunction bipolar transistors (HBTs) grown on InP substrates are emerging as an alternative HBT technology to the more widely used GaAlAs/GaAs HBTs for high performance and low-power integrated-circuit applications. However, these technologies may be vulnerable to single-event effects in the space environment. Recent testing at the University of Michigan at Ann Arbor has shown that HBT circuits are sensitive to single-event effects (SEEs). This thesis examines the effects of cosmic ray induced charge collection on AlInAs/GaInAs HBT by utilizing Silvaco's Virtual Wafer Fabrication software to design and simulate electrical properties of transistors. Two-dimensional computer simulations were performed to determine why the InP HBT is sensitive to charge collection events; whether charge collection is occurring across base-collector or base-emitter junctions; and what is causing the radiation sensitivity. Computer simulations are performed using Atlas® device simulation software created by Silvaco International, Inc®. The simulation results are compared to actual SEU test data.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Manufacturing Science and Technology, Electronics

KEYWORDS: Heterojunction Bipolar Transistor, Single-Event Upsets, Indium Phosphide, Aluminum Indium Arsenide, Gallium Indium Arsenide

ANALYSIS OF FINITE PHASED ARRAYS ON SHAPED GROUND PLANES

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Phillip E. Pace, Department of Electrical and Computer Engineering**

The objective of this thesis is to evaluate the performance of an array antenna when this is installed on a complex structure, such as those that have unusual edge contour, curved surfaces, and mixed material composition. A dipole is used as the basic array element to study the effect of various changes in the array design parameters on the gain and sidelobe level. Data is generated using a computational electromagnetics code based on the method of moments. Among the issues addressed are the curvature of the array ground plane and shaping the ground plane edges to reduce wide-angle sidelobes.

KEYWORDS: Arrays, Radiation Pattern

DoD KEY TECHNOLOGY AREA: Electronics

1998 THESIS ABSTRACTS

FEASIBILITY ANALYSIS FOR A SUBMARINE WIRELESS COMPUTER NETWORK USING COMMERCIAL-OFF-THE-SHELF COMPONENTS

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This thesis investigates the feasibility of deploying wireless local area networks (WLANs) onboard submarines. Installing wireless networks on submarines is intended to improve the productivity of the crew by leveraging the superior connectivity and data processing capabilities of commercial-off-the-shelf (COTS) wireless networking technologies. Areas specifically targeted for improvement are damage control communications and watchstander log taking.

In this thesis, the effects on wireless communications of the submarine's mostly metallic construction are examined along with potential mitigation methods. The overall requirements and specifications for a submarine wireless network are also derived. These constraints are then matched against the capabilities of existing commercial products in the mobile computing and wireless networking industries. Finally, a proof of concept system is developed and evaluated in both laboratory and submarine environments. Testing results demonstrate that a low-cost, high-performance WLAN for use in submarines is achievable using existing technologies. Additionally, recommendations are provided as to which evolving technologies have the most promise for future system improvements. This thesis work is the first part of an ongoing project that is tasked to specify, design, prototype, and test a wireless local area network for installation in the New Attack Submarine (NSSN).

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks, Spread Spectrum, PDAs, Handheld Computers

AN ANALYSIS OF LIMITATIONS IN ACTIVE CANCELLATION OF RADAR SIGNALS

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Master of Science in Electrical Engineering-September 1998

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Acoustic noise suppression has been achieved by rebroadcasting a phase-inverted copy of an incident signal, such that the two signals cancel. The same effect applies in theory to electromagnetic signals, allowing the cancellation of radar signals. This effect would supplement existing "stealth" technologies. The electromagnetic equivalence theorem provides for a straightforward theoretical analysis, and several numerical analyses demonstrate cancellation on simple wire models. The limitations of the cancellation are covered with respect to bandwidth, canceler spacing, and two canceler unit failure (error) modes. Successful cancellation is demonstrated for two canceler densities up to approximately 50 MHz, and a significant reduction in canceler effectiveness results when the two failure modes are tested.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare, Sensors

KEYWORDS: Radar, Electromagnetic Field Cancellation, Radar Cancellation, Scattering Analysis

1998 THESIS ABSTRACTS

FREQUENCY DEPENDENCE OF SINGLE EVENT UPSETS IN GALLIUM ARSENIDE METAL SEMI-CONDUCTOR FIELD EFFECT TRANSISTORS

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Single event upsets (SEUs) are the result of high-energy particles passing through transistors in electronic circuits, causing errors in flip-flops and memory circuits. Gallium Arsenide (GaAs) Metal Semiconductor Field Effect Transistors (MESFETs) are desirable for space systems due to their lower power consumption at higher frequencies. However, they are more prone to errors from high-energy particles in the space environment. The goal of this research was to explore the temporal aspects of SEUs in GaAs MESFETs to determine the causes of variation in upset rates with frequency. By performing two-dimensional simulations of inverter circuits, the fundamental building blocks of electronic storage elements, a more accurate simulation of SEUs is possible, providing greater insight into the circuit response to particle strikes as transient signals are applied. This thesis develops doping profiles to match electrical characteristics of both conventional and radiation-tolerant MESFETs using Low-Temperature grown GaAs (LTGaAs). Techniques are developed to incorporate multiple transistors in 2-D simulations, more accurately replicating circuit responses. Finally, it is shown that the response to SEUs depends on the timing of the particle strike in relation to the signal transient, resulting in a varying error rate as a function of circuit frequency.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation

KEYWORDS: GaAs, MESFET, SEU, Transient, Frequency Dependence

CLASSIFICATION OF UNDERWATER SIGNALS USING WAVELET-BASED DECOMPOSITIONS

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This thesis investigates the application of wavelet decompositions to classification applications. Two feature extraction tools are considered: Local Discriminant Bases (LDB) scheme and Power method. Several dimension reduction schemes including a newly proposed one called the Mean Separator Neural Network (MSNN) are discussed. Two types of classifiers are investigated and compared: Classification Trees (CT) and Back-Propagation Neural Network (BPNN). Classification experiments conducted on synthetic and real-world underwater signals show that: 1) the power feature extraction method is more robust to time synchronization issues than the LDB scheme is; 2) the MSNN scheme is a successful dimension reduction scheme that may be used with both LDB and Power feature extraction methods; and 3) the BPNN is a more powerful classifier than CT as it has fewer constraints than CT in partitioning the feature input space.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Classification, Wavelet Decomposition, Local Discriminant Bases (LDB), Dimension Reduction, Classification Trees (CT), Back-Propagation Neural Network (BPNN), BCM

1998 THESIS ABSTRACTS

OBJECT RECOGNITION USING 2D SENSORS AND AUTONOMOUS VEHICLE NAVIGATION ISSUES

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Master of Science in Electrical Engineering-December 1997

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Lynne L. Grewe, California State University Monterey Bay

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This research deals with the problem of extracting features from an image using wavelets and then using these features to recognize objects present in the image. This technique is applied to recognition of Unexploded Ordnance (UXO) objects. However, the concepts described here can be extended to recognition of other objects such as ships, missiles and aircrafts. This work is performed as part of an ongoing effort to develop an autonomous vehicle capable of detecting UXOs.

KEYWORDS: Image Recognition, Unexploded Ordnance, Wavelets, Neural Networks, Motion Control

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronic Warfare, Modeling and Simulation, Ground Vehicles

USING THE PEBB UNIVERSAL CONTROLLER TO MODIFY CONTROL ALGORITHMS FOR DC-TO-DC CONVERTERS AND IMPLEMENT CLOSED-LOOP CONTROL OF ARCP INVERTERS

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Robert Ashton, Department of Electrical and Computer Engineering

The objective of this thesis is two-fold. The first goal is to expand the operational capabilities of the Ship's Service Converter Module control algorithm for a DC-to-DC converter using the Universal Controller. The second goal is to investigate the use of the Universal Controller to implement a closed-loop control algorithm for an Auxiliary Resonant Commutated Pole (ARCP) power inverter. These power electronic devices are central to the development of a DC Zonal Electric Distribution System (DC ZEDS) that is scheduled for application in the twenty-first century surface combatant (SC-21). The development of appropriate control algorithms is a key element to this design process. The Universal Controller is a digital controller that was developed by personnel at the Naval Surface Warfare Center (NSWC), Annapolis, Maryland. The basic operation of the Universal Controller and the Texas Instrument TMS320C30 microprocessor architecture are described, with emphasis placed on the system control algorithms.

Previous studies have encoded and successfully tested a closed-loop control algorithm for a DC-to-DC converter. In this research endeavor, this control algorithm is expanded to include various protection circuits and a Master/Slave paralleling scheme. Finally, a closed-loop control algorithm for the ARCP inverter is encoded and recommendations for future research are outlined.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Computing and Software

KEYWORDS: DC-to-DC Buck Converter, Auxiliary Resonant Commutated Pole Inverter, Universal Controller, Closed-Loop Control of Power Inverters, Texas Instruments TMS320C30

1998 THESIS ABSTRACTS

ACOUSTIC NOISE REMOVAL BY COMBINING WIENER AND WAVELET FILTERING TECHNIQUES

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Master of Science in Electrical Engineering-June 1998

Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering

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This thesis investigates the application of Wiener filtering and wavelet techniques for the removal of noise from underwater acoustic signals. Both FIR and hR Wiener filters are applied in separate methods which involve the filtering of wavelet coefficients which have been produced through a discrete wavelet decomposition of the acoustic signal. The effectiveness of the noise removal methods is evaluated by applying them to simulated data. The combined Wiener wavelet filtering methods are compared to traditional denoising techniques which include Wiener filtering and wavelet thresholding methods.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors

KEYWORDS: Wavelet Analysis, Wiener Filtering, Denoising, Acoustic Signals

THE MACH-ZEHNDER COUPLER

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Master of Science in Applied Physics-December 1997

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This thesis is the second in a series which investigates the possibility of creating a code-shift-keying (CSK) optical receiver using single-mode 2x2 couplers and fiber optical delay lines to construct Mach-Zehnder couplers which comprise the main building block of the CSK receiver. There were two main goals of this thesis research. The first was to investigate design and construction modifications which would lower the system loss of a previously designed Mach-Zehnder coupler. As a result of this research, the system loss was reduced from 10.5 dB to 3.3 dB by changing the design to eliminate an unnecessary stage and by replacing several mechanical connections with fusion splices. The second goal was to find a method to measure the inherent phase shift of a 2x2 fiber optical coupler. Two separate methods were developed and implemented, and a third previously developed method was used to verify the results. All three methods provided experimental values between 145° and 149°. This thesis develops the theory that explains the discrepancy between the measured values and the ideal value of 180° for the inherent phase shift.

KEYWORDS: Fiber Optic Receiver, Mach-Zehnder Coupler, Interferometry

DoD KEY TECHNOLOGY AREAS: Electronics, Sensors, Command, Control, and Communications

1998 THESIS ABSTRACTS

COMPUTER MODELING OF CAPTIVE-CARRY MISSILE SIMULATOR EXPERIMENTS

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Master of Science in Systems Engineering-September 1998

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Second Reader: Robert G. Hutchins, Department of Electrical and Computer Engineering

The increasing number, diversity and sophistication of the anti-ship cruise missiles around the world in the past thirty years have led to sophisticated countermeasures. The Naval Research Laboratory has developed hardware-in-the-loop (HIL) missile simulator technology to assess the effectiveness of electronic attack (EA) countermeasures. These simulators appear in two basic configurations: the closed-loop in an anechoic chamber and the open-loop captive-carry on board a P-3 aircraft.

The objective of this thesis was to develop a comprehensive Simulink© model representing the two HIL missile simulator configurations. These models were then used to study the influence of each parameter on EA effectiveness, as measured by missile miss distance.

The development of this model now makes it possible to compare the seeker responses of the two configurations as well as to have an inexpensive way to test new approaches to combine the closed-loop missile dynamics with the open-loop environment information to obtain more accurate EA effectiveness measurements.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Anti-Ship Cruise Missiles, Electronic Attack (EA), Hardware-in-the-Loop, Missile, Simulations, ASCM Digital Model, EA Effectiveness, Miss Distance

OPTIMUM SYMMETRICAL NUMBER SYSTEM PHASE SAMPLED DIRECTION FINDING ANTENNA ARCHITECTURES

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Master of Science in Applied Physics-June 1998

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David D. Cleary, Department of Physics

A new interferometer direction finding array architecture based on the optimum symmetrical number system (OSNS) is presented. OSNS arrays are capable of unambiguous high-resolution direction finding with as few as three elements, with multiple baseline options. The OSNS DF antenna architecture being investigated uses the OSNS to decompose the analog spatial filtering operation into a number of parallel sub-operations (moduli) that are of smaller complexity. One two-element interferometer is used for each sub-operation and only requires a precision in accordance with its modulus. A much higher spatial resolution is achieved after the sub-operations are recombined. By incorporating the OSNS concept, the dynamic range of a specific configuration of antenna element spacings and comparator arrangements can be analyzed exactly. In this thesis, the OSNS DF antenna concept was demonstrated experimentally, by designing, fabricating and measuring the performance of a three-element array at 8.5 GHz. These three elements are grouped into two pairs (channels) according to the set of relatively prime moduli ($m_1 = 6$, $m_2 = 11$). A mixer is used to determine the phase difference between each pair of elements. The output voltage from the mixer in each channel is a symmetrical folding waveform that is DC biased and amplified using a summing amplifier. The output voltage of the amplifier is amplitude analyzed using a small comparator ladder. An EEPROM is used to recombine the results of these low precision channels to yield the high resolution direction of arrival (DOA). Simulated and experimental results are presented and compared.

1998 THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Direction Finding Antennas, Array Antennas, Rectangular Aperture Antennas, Open-ended Waveguides, Optimum Symmetrical Number System (OSNS), Weighted Summing Amplifier, Analog-to-Digital Converter, Comparator ladder.

FEATURE-BASED LOCALIZATION IN SONAR-EQUIPPED AUTONOMOUS MOBILE ROBOTS THROUGH HOUGH TRANSFORM AND UNSUPERVISED LEARNING NETWORK

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Master of Science in Electrical Engineering-June, 1998

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Robert G. Hutchins, Department of Electrical and Computer Engineering

As we approach the new millennium, robots are playing an increasingly important role in our everyday lives. Robotics has evolved in industrial and military applications, and unmanned space exploration promises the continued development of ever-more-complex robots. Over the past few decades, research has focused on the development of autonomous mobile robots—robots that can move about without human supervision. This brings with it several problems, however, specifically the problem of localization. How can the robot determine its own position and orientation relative to the environment around it?

Various methods of localization in mobile robots have been explored. Most of these methods, however, assume some a priori knowledge of the environment, or that the robot will have access to navigation beacons or Global Positioning Satellites. In this thesis, the foundations for feature-based localization are explored. An algorithm involving the Hough transform of range data and a neural network is developed, which enables the robot to find an unspecified number of wall-like features in its vicinity and determine the range and orientation of these walls relative to itself. Computation times are shown to be quite reasonable, and the algorithm is applied in both simulated and realworld indoor environments.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Autonomous Mobile Robots, Hough Transform, Localization, Nomad Scout Mobile Robot, Competitive Neural Networks, Data Clustering

COMMUNICATIONS VULNERABILITY ANALYSIS OF FINANCIAL TELECOMMUNICATIONS

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B.A., Pennsylvania State University, 1991

Master of Science in Systems Engineering-September 1998

Advisor: John McEachen, Department of Electrical and Computer Engineering

Second Reader: Vicente Garcia, National Security Agency Cryptologic Chair

The American defense forces, national intelligence, and law enforcement agencies are challenged with meeting high operational demands with a finite set of resources. This thesis proposes a new Information Operations tool that focuses upon using computer network analysis. Using the OPNET Modeling and Simulation software, developed, by MIL3, Inc. to demonstrate how nation states and non-governmental organizations who condone and support the sale of illegal narcotics use computers and electronic media to communicate, an Information Operations/Warfare plan can be developed to defeat its use. Furthermore, this thesis' centers its research on how to remove the incentive, money, from drug dealer's coffers; thus, making the cultivation and sale of illegal narcotics a zero sum game.

This thesis concentrates on one nation in particular, country X, to create a baseline model of its electronic financial transactions. Once a model of a nation, who sponsors criminals and terrorist to operate within its borders, is created then

1998 THESIS ABSTRACTS

this model can be tailored to fit any other nation. The strategy behind this research centers on country X's critical communications nodes and how to manipulate the nodes to serve our purpose vice their original intent.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Electronic Warfare, Modeling and Simulation

KEYWORDS: Telecommunications, OPNET, Money Laundering

AN INTEGRATED INS/GPS NAVIGATION SYSTEM FOR SMALL AUVS USING AN ASYNCHRONOUS KALMAN FILTER

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Master of Science in Electrical Engineering-June 1998

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Eric R. Bachmann, Department of Computer Science

A Small AUV Navigation System (SANS) is being developed at the Naval Postgraduate School. The SANS is an integrated INS/GPS navigation system composed of low-cost, small-size components. It is designed to demonstrate the feasibility of using a low-cost Inertial Measurement Unit (IMU) to navigate between intermittent GPS fixes.

This thesis presents recent improvements to the SANS hardware and software. The 486-based ESP computer used in the previous version of SANS is now replaced by an AMID 586DX133 based PC/104 computer to provide more computing power, reliability and compatibility with PC/104 industrial standards. The previous SANS navigation filter consisting of a complementary constant gain filter is now aided by an asynchronous Kalman filter. This navigation filter has six states for orientation estimation (constant gain) and eight states for position estimation (Kalman filtered). Low-frequency DGPS noise is explicitly modeled based on an experimentally obtained autocorrelation function. Ocean currents are also modeled as a low-frequency random process. The asynchronous nature of DGPS measurements resulting from AUV submergence or wave splash on the DGPS antennas is also taken into account by adopting an asynchronous Kalman filter as the basis for the SANS software. Matlab simulation studies of the asynchronous filter have been conducted and results documented in this thesis.

DoD KEY TECHNOLOGY AREA: Electronics, Sensor

KEYWORDS: INS, GPS, AUV, Navigation, Kalman Filter

IMPLEMENTATION OF A MULTIPLE ROBOT FRONTIER-BASED EXPLORATION SYSTEM AS A TESTBED FOR BATTLEFIELD RECONNAISSANCE SUPPORT

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B.S., University of Minnesota, June 1990**

Master of Science in Electrical Engineering-June 1998

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Second Reader: Harold Titus, Department of Electrical and Computer Engineering

Future military battlefields will see smaller forces responsible for ever increasing geographical areas. In addition, future conflicts will occur more often in urban or built-up areas. Both of these trends argue for some type of augmentation for initial reconnaissance, continued observation, and control of lines of communication and other key terrain features. Multisensor systems, mounted on a variety of robotic platforms, can provide this type of battlefield support where it is needed most. However, before costly decisions concerning the details of such systems can be made, basic research needs to be conducted regarding their most effective composition and utilization.

Prior to this time all multiple robot studies at this institution had only taken place in simulated environments. This thesis implements a real-world multiple robot system that uses a technique known as frontier-based exploration to explore and

1998 THESIS ABSTRACTS

map a laboratory or office environment. In doing so, many previously hidden aspects of multiple robot systems, unnoticeable in simulation-only studies, become evident. The results developed here are compared to results obtained elsewhere involving other robotic platforms. This research lays the foundation for future research involving multiple robots interacting as a system in a real-world environment and acting towards a common or shared goal.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors, Other (Robotics)

KEYWORDS: Robotics, Multiple Robots, Sensor Fusion, Battlefield Reconnaissance

INTEGRATING DIGITAL SIGNAL COLLECTION AND PROCESSING INTO THE SH-60R NAVAL AIR MULTI-PURPOSE PLATFORM (U)

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Master of Science in Electrical Engineering-September 1998

Advisors: Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair

Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

The capability of the SH-60R helicopter to become a BGPHEs platform combined with other IO capabilities is not planned at this time. The primary station for this aircraft will be approximately 200 nautical miles from the carrier and this position presents an opportunity for gathering intelligence. The SH-60R also possesses a unique capability in that it can relay communications and data directly to a ship via secure link. This thesis explores the possibility of incorporating a new architecture that could be adaptable for several mission scenarios. Signal processing necessary to support mission scenarios is introduced which could be incorporated into IW tactics. This thesis will begin by introducing the reader to the SH-60R aircraft and specific signal processing software. The reader will then be introduced to real world signals and the exploitation of them.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Electronic Warfare

KEYWORDS: Digital, SH-60R, ELINT, COMINT, SIGINT, MARTES

ANALYSIS OF REAL TIME EMITTER LOCATION ALGORITHMS FOR TACTICAL ELECTRONIC WARFARE AIRCRAFT

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Master of Science in Electrical Engineering-March 1998

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Second Reader: Harold A. Titus, Department of Electrical and Computer Engineering

Geographic location of radar emitters is the process of estimating an emitter's location upon the surface of the earth from direction of arrival (DOA) data for the targeted emitter. The current Emitter Location (EMLOC) algorithm utilized by the Grumman EA-6B Prowler is based on a thesis presented by Mr. Richard Opperman in June 1982. With the advent of increased processing demands on the AN/AYK-14 Tactical Computer as part of recent software upgrades to the AN/ALQ-99 Tactical Jamming System, it was hoped that a Kalman Filter, or Extended Kalman Filter based algorithm, would reduce the processing time and memory requirements for the EMLOC algorithm. This thesis compares the current algorithm and the Kalman/Extended Kalman Filters in a tactical scenario to determine if a change in the current Onboard Flight Program (OFP) should be recommended.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Kalman Filter, Extended Kalman Filter, Location Algorithm

1998 THESIS ABSTRACTS

INTEGRATING DIGITAL SIGNAL COLLECTION AND PROCESSING INTO THE EP-3E AND P-3C NAVAL AIR RECONNAISSANCE PLATFORMS (U)

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Master of Science in Systems Engineering-September 1998

and

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Herschel L. Loomis, Jr., Department of Electrical and Computer Engineering

Abstract is classified

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Space Vehicles, Battlespace Environments, Command, Control and Communications, Computing and Software, Electronics, Electronic Warfare, Human System Interface, Manpower, Personnel, and Training, Sensors, Manufacturing Science and Technology, Modeling and Simulation

KEYWORDS: MARTES, PAT, EP-3E, P-3C, SIGINT, COMINT, ELINT, Digital

ANALYSIS AND DESIGN OF RETROREFLECTORS

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Master of Science in Electrical Engineering-December 1997

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Second Reader: Phillip Pace, Department of Electrical and Computer Engineering

The enhancement of the radar cross section (RCS) of specific bodies above their normal cross section has several military and civilian applications (e.g., sailboats and decoys). This enhancement is achieved by the use of retroreflectors. Retroreflectors are simple geometric conducting structures that concentrate the reflected wave back in the direction of incidence. They are capable of producing a high RCS over a wide range of aspect angles.

This thesis examines the RCS performance of various common retroreflector geometries. The study is performed using two computational electromagnetic simulation codes: a method of moments code and a physical optics code. The contour plots of RCS are presented for different geometries as a function of frequency. For retroreflectors composed of flat plates, the plate shape is varied to determine the affect of the plate size and profile on the RCS.

KEYWORDS: RCS, Retroreflector

DoD KEY TECHNOLOGY AREA: Electronic Warfare

1998 THESIS ABSTRACTS

DEVELOPMENT OF A NARROWBAND ZOOM PROCESSING CAPABILITY USING COMMERCIAL PROCESSORS

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Murali Tummala, Department of Electrical and Computer Engineering

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into a system residing in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis develops the module responsible for narrowband zoom processing. This module allows an operator to view high resolution frequency domain data from various sensors using heterodyning and decimation techniques with processing performed by either a desktop personal computer processor or commercial digital signal processing boards. This work presents the development of the narrowband bandwidth determination and decimation sequence algorithms, the development of the heterodyning and narrowband processing using Microsoft Visual C++ as the implementation language, and the testing of the various parts of the Narrowband Pretrack module in a stand-alone Microsoft Windows application.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: DSP, Narrowband, BEARTRAP

INTEGRATING DIGITAL SIGNAL COLLECTION AND PROCESSING INTO THE EP-3E AND P-3C NAVAL AIR RECONNAISSANCE PLATFORMS (U)

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Master of Science in Space Systems Operations-June 1998

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Master of Science in Systems Engineering-September 1998

Advisors: Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair

Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

Abstract is Classified

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Space Vehicles, Battlespace Environments, Command, Control and Communications, Computing and Software, Electronics, Electronic Warfare, Human System Interface, Manpower, Personnel, and Training, Sensors, Manufacturing Science and Technology, Modeling and Simulation

KEYWORDS: MARTES, PAT, EP-3E, P-3C, SIGINT, COMINT, ELINT, Digital

1998 THESIS ABSTRACTS

CALIBRATION AND EVALUATION OF WATER SPEED INDICATOR AND COMPASS FOR THE SMALL AUTONOMOUS UNDERWATER VEHICLE NAVIGATION FILTER

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B.S., University of Idaho, 1987

Master of Science in Electrical Engineering-December 1997

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Eric Bachmann, Department of Computer Science

There are three major thrusts to this thesis. The first was to design and build a device to measure ground speed for testing the position estimating capabilities of the Small Autonomous Navigation System (SANS) filter. The ground tests consisted by placing the SANS unit on a golf cart and maneuvering it along a known track. The speed sensing device uses a bicycle wheel attached to the golf cart along with an appropriate time to speed software conversion.

The next problem was to determine if the existing paddle wheel in use would be accurate enough for the SANS to conduct underway tests. To perform this, a mechanism had to be built to channel water and measure its speed while allowing the paddle wheel to be in the flow.

Finally, the electronic compass was found to have heading dependent errors, thus a test was designed to determine its deviation. This was performed by swinging the compass using a transit aligned with its axis. This established a deviation table that was inserted into the SANS code, further refining its directional capabilities.

As a final test for determining the effectiveness of the calibrated inputs, tests were conducted that showed that the SANS filter is capable of obtaining 3 meter accuracy with no Global Positioning Update for an excess of two minutes. This is well beyond the initial goals set for the system.

KEYWORDS: Small Autonomous Navigation System, SANS, Global Positioning

DoD KEY TECHNOLOGY AREAS: Electronics, Sensors, Modeling and Simulation

PERFORMANCE ANALYSIS OF NONCOHERENT BINARY FREQUENCY SHIFT KEYING USING EQUAL GAIN COMBINING AND POST DETECTION SELECTION COMBINING OVER A NAKAGAMI FADING CHANNEL

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Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

In this thesis, the performance of a noncoherent Binary Frequency Shift Keying (BFSK) receiver using Equal Gain Combining (EGC) and Post Detection Selection Combining (PDSC) techniques over a frequency nonselective and slowly Nakagami fading channel is investigated.

Analytical and numerical results obtained for EGC are compared to those obtained for first order PDSC (PDSC-1), second order PDSC (PDSC-2), and third order PDSC (PDSC-3).

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Nakagami Fading Channel, Diversity Combining Techniques, Equal Gain Combining (EGC), Post Detection Selection Combining (PDSC)

1998 THESIS ABSTRACTS

INVESTIGATION OF HIGH FREQUENCY SHIP RADAR CROSS SECTION REDUCTION BY MEANS OF SHAPING

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Master of Science in Applied Physics-September 1998

Master of Science in Electrical Engineering-September 1998

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David D. Cleary, Department of Physics

The objective of this thesis is to investigate and evaluate the effectiveness of ship radar cross section (RCS) reduction in the high frequency (HF) band by means of shaping. The study is based on a computer simulation which uses the method-of-moments to compute the RCS of a number of conventional and shaped ship geometries. It was found that a ship with canted deckhouse walls and a standard hull had little reduction in RCS relative to a conventional ship. This result shows that shaping is not as effective at these frequencies (3-30 MHz) as it is in the optical region. The hull is the major contributor to RCS near broadside. Shaping the hull did reduce the RCS slightly for the frequencies and elevation angles investigated.

DoD KEY TECHNOLOGY AREAS: Electronics, Sensors, Surface/Under Surface Vehicles-Ships and Watercraft, Modeling and Simulation

KEYWORDS: HF Radar, Ship, RCS, Method-of-Moments, CAD

RADAR TRANSMITTER IDENTIFICATION VIA SINGLE PULSE ANALYSIS

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M.S., University of Central Florida, 1990

Doctor of Philosophy in Electrical Engineering-December 1997

Advisor: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

This dissertation proposes an entirely new method for the identification of radar transmitters based solely on a single received pulse. The method for building a mathematical model to describe a radar transmitter is discussed in full detail. Also detailed is the method for comparing these models to received radar pulses of unknown source, to determine the best match and therefore identify the source transmitter. The results of using this method on actual radar data are quite good; indeed, this method can even distinguish between different transmitters of the same make, model, and specifications.

The theoretical limits of radar transmitter identification are also explored. Specifically, a new lower bound on the optimum probability of error, applicable to any hypothesis-testing problem, is developed. This bound is applied to the radar case to give an indication of the theoretical limits of transmitter identification that cannot be exceeded.

KEYWORDS: Radar Transmitter Identification, Vector Quantization, Hidden Markov Models, Unintentional Modulation on Pulse, Specific Emitter Identification

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

1998 THESIS ABSTRACTS

MATLAB IMPLEMENTATION OF A FOURIER APPROACH TO OPTICAL WAVE PROPAGATION

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Master of Science in Electrical Engineering-September 1998

Advisor: John P. Powers, Department of Electrical and Computer Engineering

Second Reader: Ron J. Pieper, Department of Electrical and Computer Engineering

This thesis explores a MATLAB implementation of a Fourier transform approach to model and predict transient optical wave propagation through free-space. A three-step approach is adopted in this study. First, the mathematical development establishes the importance of the total impulse response as the Green's function, meeting the boundary conditions and solving the wave equation. Second, a MATLAB program is developed to simulate the mathematical model by computing and displaying the graphical representation of an optical wave's spatial distribution on a plane at a given distance from a spatially filtered source. Third, a circular excitation function is used to verify the program and then the results of another three excitations, namely the square, circularly truncated Gaussian and circularly truncated Bessel functions are similarly generated. The effort of this thesis provides an inexpensive means to analyze a transient optical wave propagation of a spatially filtered optical source.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Computing and Software

KEYWORDS: Green's Function, Spatial Impulse Response, Diffraction, MATLAB

IMPLEMENTATION AND EVALUATION OF AN INERTIAL NAVIGATION SYSTEM (INS) FOR THE SHEPHERD ROTARY VEHICLE

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Master of Science in Applied Physics-December 1997

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Xavier K. Maruyama, Department of Physics

An autonomous vehicle must be able to determine its global position even in the absence of external information input. To obtain reliable position information, this would require the integration of multiple navigation sensors and the optimal fusion of the navigation data provided by them.

The approach taken in this thesis was to implement two navigation sensors for a four-wheel drive and steer autonomous vehicle: An inertial measurement unit providing linear acceleration in three dimensions and angular velocity for the vehicle's global motion and shaft encoders providing local motion parameters. An inertial measurement unit is integrated with the Shepherd mobile robot and data acquisition and processing software is developed. Position estimation based on shaft encoder readings is implemented. The framework for future analysis including most general motion profiles have been laid.

The sensor's system performance was evaluated using three different linear motion profiles. Test results indicate that the shaft encoder provide a positioning accuracy better than 99% (typ. 7.5 mm for 1 m motion) under no slip conditions for pure translational motion. The IMU still requires further improvement to allow for both sensors to be combined to an integrated system.

KEYWORDS: Robotics, Sensors, Navigation, NPS, Shepherd, Rotary Vehicle

DoD KEY TECHNOLOGY AREAS: Sensors, Ground Vehicles

1998 THESIS ABSTRACTS

COMPARISON OF SUPER RESOLUTION ALGORITHMS WITH DIFFERENT ARRAY GEOMETRIES FOR RADIO DIRECTION FINDING

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Master of Science in Electrical Engineering-September 1998

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Second Reader: Phillip E. Pace, Department of Electrical and Computer Engineering

The objective of this thesis is to investigate and evaluate the effectiveness of modern estimation methods with different array geometries as they apply to the problem of bearing estimation. These algorithms were selected from those that apply to the multidimensional case, including MUSIC, PHD, minimum norm, and Capon's beam-former. These four techniques are chosen based on their high resolution capability, and their ability to deal with three-dimensional non-uniform arrays and can estimate both azimuth and elevation angle of arrival(AOA). Computer simulations were run for linear arrays, circular arrays, and combinations of the two. The test conditions included: (1) two closely spaced emitters and (2) various levels of additive white Gaussian noise.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors

KEYWORDS: Direction Finding, Antenna Array, Superresolution Techniques

DESIGN OF A MICROELECTRONIC CONTROLLER WITH A MIL-STD-1553 BUS INTERFACE FOR THE TACTILE SITUATION AWARENESS SYSTEM

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Electrical Engineer-September 1998

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Second Reader: Randy L. Wight, Department of Electrical and Computer Engineering

Spatial Disorientation (SD) is a triservice aviation problem that costs the Department of Defense more than \$300 million annually in destroyed aircraft and is the primary cause of pilot-related mishaps in the Navy and the Air Force. As one solution to the SD problem, the Naval Aerospace Medical Research Laboratory has developed the Tactile Situation Awareness System (TSAS). The primary objective of TSAS is to enhance pilot performance and reduce SD-related aircrew/aircraft losses by providing continuous non-visual information using the normally underutilized sensory channel of touch. Using vibrotactile stimulators, TSAS applies information taken from the aircraft's instruments to the pilot's torso. The current implementation of TSAS is a research system that is not compatible with the crowded cockpit of modern aircraft. This thesis presents a design of a microelectronic controller for TSAS compatible with tactical environments. This new system, called the Tactor Interface Microcontroller System (TIMS), incorporates the functionality of the research TSAS into a palm-sized microcontroller system and enables TSAS to communicate directly to the computerized sensory and weapons systems in combat aircraft such as the Navy F/A-18. TIMS brings the TSAS prototype out of the research stage and puts this exciting technology into the hands of the warfighter.

DoD KEY TECHNOLOGY AREAS: Electronics, Human Systems Interface

KEYWORDS: Electronics, Human Systems Interface, TSAS, Embedded System

1998 THESIS ABSTRACTS

PERFORMANCE ANALYSIS OF NONCOHERENT DIFFERENTIAL PHASE SHIFT KEYED WITH VARIOUS DIVERSITY COMBINING TECHNIQUES OVER A RICIAN FADING CHANNEL

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The error probability analysis of a noncoherent differential phase shift keyed (DPSK) receiver employing diversity combining techniques is performed. It is assumed that the system operates over a frequency non-selective, slowly fading Rician channel.

This thesis analyzes equal gain combining (EGC), selection combining (SC) and post detection selection combining (PDSC). The first two diversity combining techniques are widely used in communication systems, while PDSC is a new technique. Previous analysis of the EGC and the SC techniques shows that the EGC technique has a better performance than the SC technique in a Rayleigh fading channel. In this thesis, the effect on the performance of a noncoherent DPSK receiver using the diversity combining techniques for Rician fading is examined. It is shown that the PDSC technique provides a performance that is better than the SC but worse than the EGC technique. The PDSC technique allows a relatively simple receiver structure independent of the number of diversity branches.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Rician Fading Channel, Diversity Combining Techniques, Equal Gain Combining (EGG), Selection Combining (SC), Post Detection Selection Combining (PDSC).

DEVELOPMENT OF AN ACOUSTIC TRANSIENT ANALYSIS USER INTERFACE FOR DETECTION AND TARGET LOCALIZATION

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Second Reader: Michael K. Shields, Department of Electrical and Computer Engineering

This work is part of an ongoing effort to integrate the separate Beartrap post mission analysis tools into a system residing in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for Beartrap post mission analysis. This thesis develops the module responsible for acoustic transient detection and analysis. This module allows an operator to view time domain data from various sensors, record time of arrival data for a transient, and use the times from various buoys to calculate target position using a Time Difference of Arrival (TDOA) algorithm. The algorithm provides a closed form solution of target position and transmission time based on Time Difference of Arrival data. The accuracy of this solution depends on the accuracy of the time of arrival measurements, the accuracy of the sensor positions, and the sensor geometry. This work presents the development of the user interface using Microsoft Visual C++ as the implementation language, the development of the TDOA algorithm, and the testing of the various parts of the Transient Analysis module in a stand-alone Windows 95 application.

KEYWORDS: Transient, TDOA, Beartrap

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

1998 THESIS ABSTRACTS

ESTIMATING THE ACOUSTIC MODAL ARRIVALS USING SIGNALS TRANSMITTED FROM TWO SOUND SOURCES TO A VERTICAL LINE HYDROPHONE ARRAY IN THE 1996 SHELFBREAK PRIMER EXPERIMENT

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During the 1996 multi-institutional Shelfbreak PRIMER experiment, low frequency sound sources were moored on the continental slope south of Cape Cod. These sources transmitted phase encoded tomography signals which were monitored by vertical-line hydrophone arrays moored on the continental shelf. The measured signals were processed for the acoustic modal arrivals and their variability in time. The processing entailed pulse compression, coherent averaging, local sound-speed profile updates and an application of the Chiu-Miller-Lynch model-based modal beamforming technique. In this thesis, the signal processing procedure is discussed and the modal arrival estimates are examined. The model-based estimates are found to be of high quality, with all propagating modes individually resolved. This unambiguous separation of the high modes cannot be achieved using simple least-squares techniques because of under sampling. The temporal variability of the modal amplitudes and travel times are found to be related to ocean processes that are unique to the shelf-slope littoral environment.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Acoustics, Array, Mode, Processing

AN OPERATIONAL HIGH POWER MICROWAVE APPLICATION FOR INFORMATION OPERATIONS (U)

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Master of Science in Systems Engineering-September 1998

and

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B.S., United States Naval Academy, 1991

Master of Science in Systems Engineering-September 1998

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Second Reader: Michael A. Morgan, Department of Electrical and Computer Engineering

This thesis documents the results of a feasibility demonstration of a high power microwave application for Information Operations and recommends future improvements to the system. Success in the Information Operations (IO) and Information Warfare (IW) arena requires advanced capabilities. This thesis describes one such capability that would provide commanders with courses of action previously unavailable.

DoD KEY TECHNOLOGY AREA: Directed Energy Weapons

KEYWORDS: Information Operations, High Power Microwave

1998 THESIS ABSTRACTS

DEVELOPMENT OF ANALYSIS TOOLS AND INCORPORATION OF COMMERCIAL DIGITAL SIGNAL PROCESSORS IN A SIGNAL ANALYSIS GRAPHICAL USER INTERFACE

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Electrical Engineer-June 1998

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Murali Tummala, Department of Electrical and Computer Engineering

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into an application operating in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis develops the module responsible for Fast Time Analysis. This module allows an analyst to generate, display, and analyze broadband and narrowband sonograms collected from a BEARTRAP mission. The overall objective of the module is to quickly identify acoustic events of interest. This document describes the development of the generation and display of broadband and narrowband grams using Microsoft Visual C++ as the implementation language, the development of the tools necessary for gram analysis, the development of a supplemental digital signal processing board for increased computational power, and the testing of the various parts of the Fast Time Analysis module in a standalone Microsoft Windows application.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: DSP, Narrowband, Broadband, BEARTRAP, Graphical User Interface

A CENTRALIZED TIME-SPACE-POSITION INFORMATION ARCHITECTURE FOR ABSOLUTE TARGETING IN HIL CAPTIVE-CARRY MISSILE SIMULATOR EXPERIMENTS (U)

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Master of Science in Electrical Engineering-September 1998

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Second Reader: Al DiMattesa, Naval Research Laboratory

Captive-carry electronic warfare experiments are performed using hardware-in-the-loop (HIL) missile simulators in order to determine the effectiveness of the targeted platform's electronic attack (EA) self-protection system. To determine the EA effectiveness, these experiments require that the position of the captive-carry aircraft and other moving objects on the test range (e.g., chaff) be known precisely as a function of time. Distributed Sensor, Time-Space-Position Information systems have been used to provide this information and typically consist of two or more measurement sensors located at some distance from each other with each sensor making a measurement of the target's angle and range. These systems are very complex since they involve multiple hardware installations, complex mathematical computations for extraction of coordinate information, synchronization of multiple sensor measurements, and independent calibration of several different measurement stations. Consequently, the accuracy of the resolved target positions can be severely degraded. This thesis presents a Centralized Time-Space-Position Information Architecture for Absolute Targeting that accurately displays in geodetic coordinates, a complete pictorial presentation of a field test experiment using only the onboard sensors of the captive-carry aircraft. By successfully synchronizing and integrating data from the Inertial Navigation System (INS), the Global Positioning System (GPS), and the targeting information from several distributed HIL missile simulators, accurate displays of the test range results are provided for easy interpretation and analysis. The architecture presented also provides both manual and automatic tagging routines to analyze and evaluate specific points of interest during a particular field test scenario (e.g., missile transfers lock to decoy). Actual captive-carry field test results using anti-ship cruise missile HIL simulators are presented in order to demonstrate the advantages of this approach.

1998 THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Absolute Targeting, ASCM HIL Simulators, Captive-Carry Field Tests, Sensor Synchronization, GPS, INS, Track Tagging

PERFORMANCE ANALYSIS OF DIFFERENTIAL PHASE SHIFT KEYED SIGNALS WITH SELECTION COMBINING AND CONVOLUTIONAL CODING IN FADING CHANNEL

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The performance analysis of a differential phase shift keyed (DPSK) communications system, operating in a Rayleigh fading environment, employing convolutional coding and diversity processing is presented. The receiver is the conventional square-law DPSK receiver using soft-decision convolutional decoding. The computationally efficient union bound technique is utilized to evaluate the system performance.

The coded and uncoded system performances of various diversity combining techniques are evaluated and compared. The combining techniques considered include equal gain combining (EGC), selection combining (SC), and a generalization of SC, whereby two or three signals with the two or three largest amplitudes are noncoherently combined. This generalized method is called second or third order SC and denoted as SC2 or SC3, respectively. Numerical results indicate that coded systems with SC2 and SC3 techniques significantly enhance the bit-error rate (BER) performance relative to that achievable with SC.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Diversity, Convolutional Coding, Decision Decoding, Rayleigh Fading, Numerical Analysis

AN ANALYSIS OF A BROADBAND MULTI-CARRIER CODE DIVISION MULTIPLE ACCESS (CDMA) CELLULAR COMMUNICATIONS SYSTEM

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Master of Science in Electrical Engineering-September 1998

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The integration of land, sea, and air forces within the littoral environment will require fading resistant, high data rate, non-exploitable communications. The large volumes of video and data information, i.e. Internet access, video teleconferencing, and data transfer, required to support the war fighter within a Joint Task Force demands technologies that reduce the interference imposed by poor terrestrial and atmospheric conditions. In order to minimize the effect of frequency-selective fading that occurs in these conditions and to provide high data rate communications, this thesis presents the analysis of a broadband cellular system featuring a multicarrier, code division multiple access (CDMA) method. The system designed complies with Federal Communication Commission broadband cellular standards and uses CDMA to reduce the probabilities of detection and interception as well as providing for multiple access, which in conjunction with the multicarrier approach enables on demand access to high data rate communications.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Littoral Communications, Analysis, Cellular, CDMA, Broadband, Multicarrier

1998 THESIS ABSTRACTS

PERFORMANCE ANALYSIS OF BINARY FSK SIGNALS WITH L-FOLD DIVERSITY SELECTION COMBINING TECHNIQUES IN A NAKAGAMI-M FADING CHANNEL

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Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

This thesis investigates the performance analysis of a non-coherent Binary Frequency Shift Keying (BFSK) receiver using Selection Combining techniques over a frequency non-selective, slowly fading Nakagami channel. These techniques are independent of the number of diversity branches, so simpler receivers can be employed.

First order selection Combining (SC), second order Selection Combining (SC-2), and third order Selection Combining (SC-3) techniques are evaluated and compared to each other. Numerical results show that the performance improves as the order of Selection Combining techniques increases.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Nakagami -M Fading Channel, Diversity Combining Techniques, Selection Combining (SC)

ROBOTIC MANIPULATION ON A MOVING PLATFORM UTILIZING FORCE SENSING AND SONAR RANGING

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Robotic manipulators are widely used in industry where the environment may be too hostile for workers. However, their application has been limited to an industrial setting where the robot is mounted on a stationary base. It is of great interest to expand the application of the robot manipulator to where it is mounted on an autonomous delivery vehicle. This application would enable the delivery vehicle not only to locate objects in a hostile environment, but also to perform tasks that would entirely remove the human being from the hostile environment. This thesis explores the feasibility of implementing a manipulator on an autonomous vehicle. A Zebra-ZERO Force Control Robot is mounted on a moving platform for feasibility simulations of an autonomous delivery vehicle. The Zebra-ZERO system consists primarily of a robotic arm with six degrees of freedom, a six-axis force sensor mounted at the end of the manipulator, and supporting computer hardware and software. In this thesis, the capability of the Zebra-ZERO system is expanded by integrating it with an external sonar ranging system. The sonar ranging system provides range feedback that is critical for positioning the manipulator while it is mounted on a moving platform. Test results demonstrate that the manipulator mounted on a moving platform is able to compensate for random platform motions and successfully perform various manipulation tasks.

DoD KEY TECHNOLOGY AREA: (Other Robotics)

KEYWORDS: Control, Zebra-ZERO, Force Sensor, Sonar Ranging, Robot Manipulator

1998 THESIS ABSTRACTS

FREQUENCY REUSE THROUGH RADIO FREQUENCY (RF) POWER MANAGEMENT IN SHIP-TO-SHIP DATA NETWORKS

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A proposed U.S. Navy ship-to-ship, line-of-sight, high-data-rate communication system is analyzed. Because of the limited bandwidth available in the UHF band, it is desired to reuse a frequency channel at the shortest possible range. By limiting the radiated power to the minimum required to establish a desired quality of service, the channel can be reused at considerably shorter ranges than when the transmitter output power is fixed to the maximum available. Frequency reuse, however, introduces the problem of cochannel interference which degrades system performance.

A computer simulation was developed to determine the bit error rate (BER) of a QPSK system in a Ricean fading channel with one cochannel interferer. The simulation generates plots of energy per bit to one-sided noise power spectral density ratio (E_b/N_0) versus BER. Simulation results are used to compute the minimum range (R) at which the channel can be reused while maintaining an average BER of 10^{-6} . The results show that even when no power control is used the channel can be reused at a range, R, of approximately 45 kilometers. This range can be reduced to less than 20 kilometers if an interfering ship can reduce its output power by 30 dB.

KEYWORDS: Radiated Power Control, Frequency Reuse, Cochannel Interference, Ship-to-Ship Data Networks, Reuse Range, QPSK, BER, Fading Channel

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

OPNET IMPLEMENTATION OF SPREAD SPECTRUM NETWORK FOR VOICE AND DATA DISTRIBUTION

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Tri Ha, Department of Electrical and Computer Engineering

This thesis presents an OPNET model and simulation of a single cell wireless communications system within a proposed expeditionary warfare communications network. The focus of this thesis is to model and implement data and voice traffic generation, slotted ALOHA medium access control protocol, and direct sequence spread spectrum code division multiple access (CDMA) mechanisms in OPNET. The RF channel is modeled as both a Rayleigh fading channel and a non-fading noise limited channel. Simulation results evaluating the induced BER and multiple access implementation are presented.

KEYWORDS: OPNET, CDMA, Spread Spectrum, Slotted ALOHA, Medium Access Control, Expeditionary Warfare Communications

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

1998 THESIS ABSTRACTS

THEATER BALLISTIC MISSILE DEFENSE--MULTISENSOR FUSION, TARGETING, AND TRACKING TECHNIQUES

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The Gulf War illustrated how important ballistic missile defenses have become to the United States. The study of intercepting Theatre Ballistic Missiles (TBMs) in their boost phase was prompted by concerns about the widespread dissemination of submunitions and the differentiation of decoys from actual warheads released early in the missile's midcourse flight. Boost Phase Intercept (BPI) would alleviate this problem by destroying the enemy's ballistic missile in the missile's launch phase, thereby causing the lethal payload and debris from the engagement to fall back on the aggressor. This thesis focuses on the development of missile tracking algorithms to be used in the boost phase of TBMs. A missile encounters significant changes in velocity, acceleration, and direction during the boost phase, making it difficult to track. Extended Kalman filter (EKF), Alpha-Beta-Gamma filter, and Interacting Multiple Model (IMM) filtering techniques are developed to determine the missile tracking accuracy of TBMs during boost phase. Simulation results and actual TBM profiles from test data are presented to verify the tracking accuracy utilizing different filtering techniques.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Kalman Filter, Alpha-Beta-Gamma Filter, Interacting Multiple Models, Theater Ballistic Missile Defense

DESIGN, CONSTRUCTION AND TESTING OF AN AUTONOMOUS MINE HUNTER

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Landmine detection is an immense technological problem. A small, low power metal detector would find application in concert with other search technologies. A detection circuit was designed and constructed consisting of a search coil and a CMOS exclusive OR gate forming an oscillator. This was interfaced to a microprocessor which counted the pulses from the oscillator and decided whether a detection had been made. Detection range for an anti-personnel mine like object was 14 cm at the coil centerline. A robot platform to autonomously search for landmines was constructed.

KEYWORDS: Landmine, Induction, Robot, Microprocessor

DoD KEY TECHNOLOGY AREA: Sensors

REFRACTIVE CONDITION IN THE CARIBBEAN SEA AND ITS EFFECT ON RADAR SYSTEMS

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Vertical gradients of pressure, temperature and humidity of the troposphere exert a strong influence over propagation of VHF, UHF, and SHF frequencies. These frequencies are associated with aircraft communications, radars and satellite communications, so it is important in military operations to collect precise and timely data from atmospheric conditions.

1998 THESIS ABSTRACTS

In this thesis programs from EREPS were used to assess refractive conditions in the Caribbean Sea against selected radar systems. Data given by SDS from radiosonde stations located in MS 43 and 44 were used as input for COVER and PROPR programs. Outputs from COVER are analyzed to find Optimal Altitude to Avoid Detection (OAAD) for a low-flying target. Outputs from PROPR using climatological data given by SDS and Optimal Altitude to Avoid Detection from COVER was used to verify OAAD against selected land- and ship-mounted radars operating in the Caribbean Sea. Finally, a system under development, TDROP is introduced in response to requirements for timely and exact data, in order to enhance the tactical data collection process.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Refractive Conditions, Air Defense, Radar Systems

LOW LATITUDE IONOSPHERIC EFFECTS ON RADIOWAVE PROPAGATION

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David D. Cleary, Department of Physics

Kenneth L. Davidson, Department of Meteorology

This dissertation provides experimental observations and analyses that associate low-latitude transionospheric signal scintillation with transequatorial VHF radio propagation and errors in transionospheric geopositioning.

The experiment observed equatorial-region ionospheric total electron content (TEC) derived from Global Positioning System (GPS) signals using receivers on Oahu, Hawaii, Christmas Island, and Rarotonga, Cook Islands. The experiment simultaneously measured VHF transequatorial propagation of VHF television signals from Hawaii to Rarotonga.

Analysis shows that a moving second moment of vertical-equivalent TEC strongly correlates to each VHF transequatorial radio propagation event. From experimental observation analysis, the author develops models for prediction of TEP and time-space distribution of low-latitude transionospheric scintillation.

The author also develops equations that show the potential errors in time, frequency, and angle used in geopositioning solutions. These three parameters are potentially correctable using these techniques.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Low-Latitude, Ionosphere, Equatorial, Scintillation, Geopositioning, Global Positioning System, GPS, Total Electron Content, TEC, Transequatorial Propagation, TEP

IT-21 COMPLIANT CONTROLLED ACCESS TO INTERNET WEB PAGES

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Second Reader: Daniel F. Warren, Department of Computer Science

Although numerous resources are available to achieve Internet presence by creating and publishing a web site, security and access control within the site are very limited. The Navy's support of the IT-21 initiative embracing the Microsoft®

1998 THESIS ABSTRACTS

Windows NT® operating system (OS) provides solutions to not only restrict entry to the site, but also to control access to content on the web page.

Work detailed in this thesis addresses the issue of security by exploring the Windows NT OS and activating its inherent security features to protect the overall system from intrusion and attacks from the Internet. The web pages are published using Microsoft® Internet Information Server 4.0 (IIS) and FrontPage™ 98. Access is controlled by issuing certificates from the resident Microsoft® certificate Server software package or remotely by VeriSign™ OnSite service. Windows NT and IIS permit a certificate to be mapped to a system account to further define the level of access assigned to each user down to the file level.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronic Warfare

KEYWORDS: IT-21, Microsoft Windows NT, Microsoft Internet Information Server, Certificates

DETECTION AND CLASSIFICATION OF DIGITAL COMMUNICATION SIGNALS USING SECOND- AND HIGHER-ORDER CYCLOSTATIONARY FEATURES (PART I/II) (U)

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Master of Science in Electrical Engineering-June 1998

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Conventional detection and classification techniques with regards to digital communications rely primarily on one or a combination of the following: Knowledge that a single known signal is present or absent, *a priori* knowledge of modulation parameters of multiple possible signals; energy or power measurements; temporal or spectral feature measurement. Though these techniques are successful in many instances, they are severely limited in significant additive white Gaussian noise (AWGN) and co-channel interference. By processing the signals as cyclostationary, a new set of features can be obtained that remain uniquely identifiable in the presence of strong noise and other signals. Two such signal processing approaches are tested here. The Automatic Signal Classifier (ASC) exploits second-order cyclostationarity via the spectral correlation function (SCF), while higher-order cyclostationarity (HOCS) is exploited via the temporal cumulant function (TCF) in the HOCS-Based Classifier (HBC). These detection and classification algorithms demonstrate a signal-selectivity property that renders them inherently more tolerant to noise and interference in a series of tests conducted first with simulated digital communications and secondly with actual transmitted digital communications.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Sensors

KEYWORDS: SIGINT, Signal Processing, Cyclostationary, Spectral Correlation, Temporal Cumulants

1998 THESIS ABSTRACTS

AUDITORY-VISUAL CROSS-MODAL PERCEPTION PHENOMENA

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The quality of realism in virtual environments is typically considered to be a function of visual and audio fidelity mutually exclusive of each other. However, the virtual environment participant, being human, is multi-modal by nature. Therefore, in order to more accurately validate the levels of auditory and visual fidelity required in a virtual environment, a better understanding is needed of the intersensory or cross-modal effects between the auditory and visual sense modalities.

To identify whether any pertinent auditory-visual cross-modal perception phenomena exist, 108 subjects participated in three main experiments which were completely automated using HTML, Java, and JavaScript computer programming languages. Visual and auditory display quality perception were measured intramodally and intermodally by manipulating visual display pixel resolution and Gaussian white noise level and by manipulating auditory display sampling frequency and Gaussian white noise level.

Statistically significant results indicate that 1) medium or high-quality auditory displays coupled with high-quality visual displays increase the quality perception of the visual displays relative to the evaluation of the visual display alone, and 2) low-quality auditory displays coupled with high-quality visual displays decrease the quality perception of the auditory displays relative to the evaluation of the auditory display alone. These findings strongly suggest that the quality of realism in virtual environments must be a function of both auditory and visual display fidelities inclusive of each other.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Modeling and Simulation

KEYWORDS: Virtual Environment, Auditory Display, Visual Display, Perception, Cross Modal, Fidelity, Experimental Design

A WIDEBAND MULTICARRIER CODE DIVISION MULTIPLE ACCESS (CDMA) CELLULAR COMMUNICATIONS SYSTEM

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Master of Science in Electrical Engineering-September 1998

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Second Reader: R. Clark Robertson, Department of Electrical and Computer Engineering

The demand for mobile access to high data rate communications services such as video teleconferencing, Internet access, or file transfer continues to grow rapidly for a wide variety of military as well as commercial applications. Existing mobile narrowband cellular communications systems do not have sufficient bandwidth to support high data rate applications. Simply increasing the bandwidth of existing cellular systems to support higher data rates results in a significant degradation in signal quality and reliability due to frequency selective fading. The wideband cellular system design presented in this thesis features a multicarrier approach that minimizes frequency selective fading for very high data rate applications and a dual mode reverse channel that facilitates efficient utilization of bandwidth for low to very high data rate applications.

1998 THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Cellular, CDMA, Wideband, Multicarrier

**PERFORMANCE ANALYSIS OF NONCOHERENT DIFFERENTIAL
PHASE SHIFT KEYING USING POST-DETECTION SELECTION
COMBINING OVER A RAYLEIGH FADING CHANNEL**

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Master of Science in Electrical Engineering-June 1998

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Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

In this thesis, the performance analysis of a noncoherent Differential Phase Shift Keying (DPSK) receiver using Post-Detection Selection Combining techniques over a Rayleigh fading channel is investigated. Post-Detection Selection Combining (PDSC) is evaluated and compared to Equal Gain Combining (EGC) and Selection Combining (SC), the two common diversity techniques discussed in the literature. Numerical results obtained for Post-Detection Selection Combining are compared to Selection Combining and Equal Gain Combining. The Post-Detection Selection Combining method is shown to be superior to the Selection Combining method but inferior to Equal Gain Combining method for a non-coherent DPSK receiver operating over a Rayleigh fading channel.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Rayleigh Fading Channel, Diversity Combining Techniques, Equal Gain Combining (EGC), Selection Combining (SC), Post-Detection Selection Combining (PDSC)

**PERFORMANCE ANALYSIS OF A SLOW FREQUENCY HOPPED, NONCOHERENT
BINARY FREQUENCY-SHIFT KEYING COMMUNICATION SYSTEM WITH
RATE 1/2 CONVOLUTIONAL CODING AND SOFT DECISION VITERBI DETECTION
OVER A RICEAN FADING CHANNEL WITH PARTIAL-BAND NOISE JAMMING**

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Master of Science in Electrical Engineering-March 1998

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Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

A performance analysis of a slow frequency-hopped, noncoherent binary frequency-shift keying (SFH/NCBFSK) communication system with rate 1/2 convolutional coding and soft decision Viterbi detection in the presence of partial-band noise jamming is performed. The effect of additive white Gaussian noise is also considered. The analysis is performed for both a non-fading channel and a Ricean fading channel. The system's performance is severely degraded by partial-band noise jamming. By way of comparison the analysis is also performed when the system utilizes hard decision Viterbi detection and for a system utilizing noise-normalized combining with soft decision Viterbi detection. In both cases a significant increase in the system's immunity to the effects of partial-band noise jamming is achieved.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Spread Spectrum Communications, Digital Communications, Partial-band Jamming, Fading Channel, Frequency-Hopped Spread Spectrum Communications

1998 THESIS ABSTRACTS

CHANNEL ALLOCATION IN WIRELESS INTEGRATED SERVICES NETWORKS FOR LOW-BIT-RATE APPLICATIONS

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This work addresses issues related to the design and performance of a wireless integrated services network with emphasis on a tactical framework. We propose an asynchronous transfer mode (ATM)-like protocol architecture for the mobile network, which is an extension of schemes proposed in the literature. A medium-access-control (MAC) scheme, based on slot reservation by the remotes, is proposed for the network. Traffic models for low-bit-rate applications, suitable for low-capacity channels, such as a multiple-access (macrocell) wireless network, are presented. New bi-directional speech-conversation and bursty data models are proposed.

The issue of scheduling in wireline integrated services networks is thoroughly addressed and new algorithms are proposed. An analytical scheme to obtain the required (static) capacity for homogeneous sources based on their Markov-chain characterization is provided. A necessary condition for optimality of a scheduling algorithm is the balance of cell-loss-probability (CLP) ratios to values approaching 1 from below, on the boundary of the admissible region. The balanced-CLP-ratio (BCLPR) algorithm satisfies this condition but ignores the deadlines of the cells. The shortest time to extinction (STE) with BCLPR (STEBR) algorithm, proposed here for the first time, utilizes the earliest-deadline-first concept while satisfying the necessary condition. A proof is provided to show that the STEBR decisions are optimal at each service slot given that no information about future traffic arrivals is available. Simulation results indicate that STEBR admits more sources and yields larger normalized channel throughput (by up to 4%) than STE.

The wireless network presents a case of distributed queues at the command post (CP) and in the remotes, making channel allocation more involved compared to scheduling in wireline systems. Based on the schedulers discussed for the wireline queue, corresponding algorithms for operation in the wireless network are developed. The cases of partial and complete status reports of the remotes are investigated as a function of the network load in five representative scenarios. The following (descending) order of performance under both partial and complete status reports is maintained in all scenarios: STEBR, STE, BCLPR, and static allocation. Performance of the schedulers using partial or complete status reports depends on the value of the normalized throughput. The complete-status mechanism is preferred whenever the normalized throughput is smaller than 0.70-0.75; partial status reports are sufficient for normalized throughput larger than 0.70-0.75. A hybrid approach that makes use of this outcome is proposed to best utilize the available channel capacity under all possible levels of network load.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications, Modeling and Simulation, Other (Networking)

KEYWORDS: B-ISDN, ATM, MAC, Scheduling, Channel Allocation, Mobile Networks, Low-Bit-Rate Source Models

INTEGRATION OF MARTES AND PAT CRYPTOLOGIC TOOLKITS FOR THE INFORMATION WARRIOR

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Master of Science in Electrical Engineering-March 1998

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Second Reader: Herschel Loomis, Department of Electrical and Computer Engineering

A number of Cryptologic tools have been created over the past two decades to assist in national intelligence gathering tasks. Among the current tools being used to aid NSA Cryptologic efforts are the MARTES and PAT software programs. This

1998 THESIS ABSTRACTS

thesis will begin by discussing a need for such software tools in the world today. After examining the MARTES and PAT software toolkits to understand exactly how they perform their respective Cryptologic functions, detailed examples of MARTES and PAT processing and analysis will follow, showing the effectiveness of each program. The final discussion will examine why MARTES should integrate the PAT program into its available toolkits. Logistic and operational issues associated with such an integration will also be explored before recommending future areas of study.

KEYWORDS: MARTES, PAT, TINKERTOY, SIGINT, Cryptology, National Security Agency

DoD KEY TECHNOLOGY AREA: Other (Information Operations)

THE VLSI IMPLEMENTATION OF A GENERALIZED IMMITTANCE CONVERTER SWITCHED CAPACITOR FILTER

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Master of Science in Electrical Engineering-March 1998

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In this research, the design and VLSI implementation of a digitally programmable active analog filter, based on the Generalized Immittance Converter (GIC) circuit, are presented. The programmable features include the filter type (band-pass, high-pass, low-pass or notch), the center or cut-off frequency, and the quality factor. Switched capacitor networks are used to implement resistances. The design was first simulated and then implemented on a wire-wrap board and tested. The circuit was then modeled and re-simulated using the Cadence Design Tools software package. Once the modeled circuit passes all design rule checks the final chip design was then submitted for fabrication. This research project will help provide a knowledge base for using Cadence software for VLSI CMOS design. Once the chip has been fabricated and tested it will provide a base for further development of stray insensitive VLSI design of analog circuits.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Switched Capacitor, Generalized Immittance Converter, VLSI, Cadence

RADAR CROSS SECTION REDUCTION: GEOMETRIC CONTROL OF DISCONTINUITIES USING SERRATED EDGES

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The objective of this thesis is to investigate and evaluate the effectiveness of radar cross section (RCS) reduction by means of the geometric control of discontinuities using serrated edges. Although the use of serrated edges for RCS reduction can be clearly seen on stealth aircraft such as the Northrop B-2, and was mentioned in several papers and references, not much data on the reduction magnitude, the associated geometry, or the design methodology are available in the open literature. Parameters of interest include the number of basic serration cells (triangles) required per wavelength, and the aspect ratio of the triangles that form the zig zags. An infinitely thin metallic plate is considered for the analysis. The RCS of such a plate with serrated edges is computed and compared against the RCS of a plate of the same sized without serrated edges. The infinitely thin assumption is valid if the wing of the aircraft, which is represented by the plate, is thin compared to the wavelength. The results obtained show significant reduction in RCS.

1998 THESIS ABSTRACTS

KEYWORDS: Radar Cross Section, Edge Diffraction, Method of Moments

DoD KEY TECHNOLOGY AREA: Electronics

PHOENIX AUTONOMOUS UNDERWATER VEHICLE (AUV): NETWORKED CONTROL OF MULTIPLE ANALOG AND DIGITAL DEVICES USING LONTALK

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The purpose of this thesis is to simplify analog and digital device control inside the *Phoenix* autonomous underwater vehicle (AUV). *Phoenix* is required to process many data information streams associated with a variety of different sensors. Real-time processing is required both for input sensing and for output directing. As presently configured, hardware devices aboard the *Phoenix* are manually connected and configured using parallel ports, serial ports, analog-to-digital (A/D) and digital-to-analog (D/A) controller hardware. Current hardware control within *Phoenix* connects all devices individually to a single computer. This approach is cumbersome, error-prone and does not scale.

This project investigates the feasibility of using Echelon LonWorks hardware and LonTalk protocol as a faster and scalable networked robot control system. LonWorks/LonTalk is a flexible A/D D/A hardware networking technology that provides reliable communication, decentralized topology with no single point of failure, easy extensibility, excellent throughput, and interoperability for a wide variety of hardware.

This project builds and tests a prototype LonTalk network that connects all *Phoenix* devices. This network demonstrates the capability of using LonWorks to control various types of hardware and support rapid component integration onboard the *Phoenix*. Successful demonstration of a LonTalk solution eliminates a critical barrier to *Phoenix* progress and makes robot execution much more robust.

KEYWORDS: Autonomous Underwater Vehicle, AUV, Networked Control, LonWorks Technology, LonTalk, LonBuilder

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles-Ships and Watercraft

A DIGITAL IMAGE SYNTHESIZER FOR INVERSE SYNTHETIC APERTURE RADAR (ISAR) COUNTER-TARGETING

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Inverse Synthetic Aperture Radar (ISAR) is a version of SAR that can be used operationally to image targets such as ships, aircraft, and space objects. It falls under the genre of imaging radars, since an ISAR image contains information on range, cross-range, and reflectivity (radar cross-section) of the target. Active deception, such as the use of false targets, requires special consideration against these types of radars. The purpose of this thesis is to study, design, and develop a hardware "digital image synthesizer" prototype using Field Programmable Gate Arrays (FPGA) capable of producing coherent false target images on such radars. The proposed hardware uses digital tapped-delay lines for time-interval (range gate) generation and the use of Doppler focussing and radar cross-section blocks for frequency and gain modulations respectively. The suite of simulation software, including a bit-and-architecturally true simulator, format conversion files, visual basic program and hardware are developed to demonstrate the concept of the digital image synthesizer. Moreover, the hardware results match those from the bit-and-architecture simulator's results closely.

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DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Inverse Synthetic Aperture Radar, Countermeasure

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